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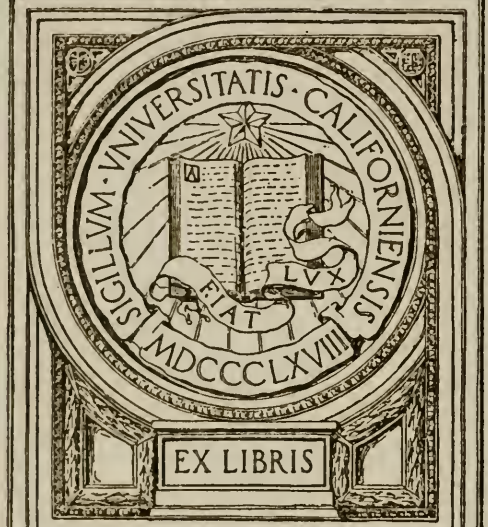
EXCHANGE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No. 6

The Habits, Anatomy, and Embryology of the Giant Scallop, (Pecten tenuicostatus, Mighels)

BY

GILMAN ARTHUR DREW
Professor of Biology

ORONO, MAINE
September, 1906

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EXCHANGE

THE GIANT SCALLOP (*Pecten tenuicostatus,* Mighels.)

Most of the material upon which these observations were made was secured near Bass Harbor, Mount Desert Island, Maine, during the summer of 1901. Scallops in that region are fairly abundant but are now for the most part confined to water 40 fathoms or more in depth and are accordingly only to be obtained by dredging.

The scallop industry of Maine has undergone some changes since the appearance of Smith's (28) paper in 1889, but on the whole the changes are not very important. Some of the beds have run out so they are not profitable to work, and others have been discovered. Most of the good beds are now in water of from 40 to 60 fathoms and the scallops are somewhat smaller than in former years but the methods of catching them do not seem to have changed much.

The majority of lamellibranchs are adapted for burrowing more or less in mud or sand, are elongated, a shape that makes burrowing easy, and are provided with two adductor muscles for closing the shell, a desirable number for a shell and body of this shape. Such animals usually move very slowly, by thrusting the foot out into the mud, swelling its end to form an anchor, and then drawing the shell with the inclosed body to the position of the anchored foot. The shell may, or may not be capable of closing tightly, this being dependent in part upon how deep the animal burrows, and accordingly how well it is protected by the overlying mud, and in part by other conditions. Such forms, when disturbed, usually close the shell rather slowly and keep it closed until probable danger is past.

It is common for lamellibranchs that live in or about the mud or sand to make use of a current of water, which they

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throw from the shell by rather suddenly closing the shell, to free the mantle chamber of the dirt that gains entrance. The ability to form a strong current is much better developed in some forms than in others, the difference apparently depending upon the ease with which dirt can be dislodged. Thus in the fresh-water mussel which lives near the surface of the mud, with at least a portion of the shell valves protruding above the surface, the current produced is not nearly so strong as in the case of the soft-shelled clam, Mya arenaria, which lives deeply buried in the mud where the dirt that gains entrance has to be elevated some distance, and where mud in suspension, caused by waves and tidal currents combined, is frequently considerable.

Many forms of lamellibranchs when put into aquaria may move some distance along the bottom by thus squirting water from the shell. This is true with Yoldia, Angulus, Mya and a large number of other forms, and at least one form, Solenomya, (6) swims freely in the water by producing a somewhat similar current of water. As such a current of water is primarily of service in cleaning the mantle chamber and is used habitually for locomotion by only a few forms, it seems quite possible that those forms that do use it for locomotion may have simply perfected an already existing mechanism primarily designed for another purpose.

Pecten is one of the ablest swimmers among lamellibranchs. The whole structure of the animal is modified for this purpose. The valves have become rounded in outline, flattened, and comparatively light. The anterior adductor muscle has been lost, and the posterior adductor muscle, which is very powerful, is situated near the middle of the body. The cartilage has become well developed so the shell may be opened quickly when the muscle relaxes, and the hinge line is straight so there may be no unnecessary strains in opening and in closing the shell. Each gill is attached by one lamella only, so water in the temporary cloacal chamber may be thrown out without injuring the gills, and the gills and margins of the mantle are provided with muscles to withdraw them from the margins of the shell when the shell is closed. Furthermore the margins of the mantle are provided with in-folded ridges and with circular muscles so it is possible to direct the current of water which issues from the shell in the required direction.

That Pecten makes use of its ability to swim in escaping from its enemies no one can doubt who has seen the shallow water species, Pecten irradians, scatter when disturbed. How it becomes acquainted with the presence of enemies is more a matter of surmise than of experiment. That the tentacles are exceedingly sensitive to touch is well known, and they may be of great service in detecting disturbances in the water. That the eyes are physically optical instruments that may produce distinct images there is every reason to believe, but it seems to be difficult to get responses from specimens in aquaria that are without question due to the sense of vision. No experiments definitely to test their sense of vision have been devised, but it is very probable that the eyes are important organs in detecting the approach of enemies in shallow water where light is sufficient. The shallow water scallop is known to migrate between shallow and deeper water at different seasons of the year. Whether the migration is due to search for food, temperature of the water, enemies, or location for spawning, or to a combination of factors, is not known. The giant scallops seem to shift their position from time to time, but as they always remain in comparatively deep water, the movement cannot be accounted for by either a change in temperature or spawning. It is most likely due to either continued disturbances by dredging, or enemies, or to lack of food. The latter is the usual reason assigned.

It is not entirely certain what relationship Pecten bears to the usual form of lamellibranch as regards positions of parts. In lamellibranchs that are supplied with two practically equal adductor muscles, a line connecting the two adductors runs nearly lengthwise of the animal. In such a case the hinge line is more or less dorsal, one end is anterior, and the other posterior. When one of the muscles disappears, as is the case with Pecten, one of the landmarks disappears and it becomes more difficult to locate the direction of parts. Inasmuch as the hinge line is usually dorsal, it is very natural to look at the hinge line of this form as dorsal, and for matters of description it is convenient to so consider it. If, however, the position that the anterior adductor would have occupied, had it been retained, be considered, the position of the mouth, foot and heart indicate that it would have to be placed much nearer the hinge line than

the present position of the posterior adductor muscle, the muscle that is retained. If this is the case, it becomes evident that the loss of the anterior adductor muscle has been accompanied by a general reduction of the anterior part of the body, so a large part of the body of Pecten is to be considered morphologically posterior. This supposition seems to be borne out by the nervous system, and the vascular system of the mantle, as well as by the extent and position of organs. In most forms the margin of each lobe of the mantle is supplied with a posterior and an anterior pallial nerve of approximately equal size. These nerves supply the muscles and sense organs of the margins, and, in many forms at least, unite with each other so they form a continuous connection between the cerebral and the visceral ganglia. In Pecten, not only is this the case, but the nerve in the margin of the mantle is joined at intervals for nearly its whole length by nerves from the visceral ganglia (fig. 15). On the other hand, it is joined only in the region of the anterior ear by nerves from the cerebral ganglia. The visceral ganglia are the important ganglia of the animal, and both the cerebral and pedal ganglia are greatly reduced.

The blood is supplied to the mantle very largely by the posterior pallial arteries (fig. 9). The anterior pallial arteries are comparatively small, and while they are connected with the posterior pallial arteries, the size and character of the vessels indicates that the junction is probably very near the anterior wing.

Considering everything, it seems likely that the longitudinal axis of the body could be morphologically represented by a line drawn from near the hinge extremity of the anterior ear to the middle of the adductor muscle, and that a very small portion of the scallop is anterior.

The only portion of the scallop that is eaten is the adductor muscle, which is proportionately very large but certainly forms less than one-half of the bulk of the soft parts of the animal. There seems to be no good reason why the remainder of the animal should not be eaten. The margins of the mantle are rather tough but not more so than the neck (siphons) of the soft shelled clam. The probable reason that all but the muscle of the scallop is discarded, while in other forms the whole body

is eaten, is that in the scallop many portions are highly colored. The visceral mass of the female is bright pink and the margins of the mantle are usually very conspicuously colored with yellows, browns, and black. Although such colors are not considered to be objectionable in many foods, they are not the usual colors for "shell-fish" and accordingly are looked upon with disfavor.

SHELL.

All members of the genus Pecten are provided with shells of a very characteristic shape. The shells are rounded, inequivalved and eared; the hinge line is straight and runs the length of the margin formed by the ears, is not provided with teeth or with a conspicuous hinge ligament and is provided with a large cartilage that is placed immediately between the beaks of the two valves.

All of the members of the genus have somewhat similar habits, are provided with numerous sense organs and are capable of swimming by clapping the shell valves together. A very heavy shell, massive teeth, or a small cartilage would not be adapted for swimming in this manner, where lightness and speed of movement are essential. A rounded outline is consistent with such progression, and the presence of numerous sense organs is important, for these animals live in positions unusually exposed to the attacks of enemies.

The shell of this particular species (figs. 1 to 7) is somewhat longer than wide and rather flat. The dimensions of a good sized specimen may be given as length 7 inches, width 6½ inches and thickness 1½ inches. The proportional thickness differs more than the other two dimensions, varying from a little under 1½ inches to a little over 1¾ inches in specimens corresponding to the other dimensions given. The two valves are of about the same weight, but the right valve, that on which the animal habitually lies, is much flatter than the left (fig. 19), lighter in color and has a rather prominent rounded notch where the anterior wing joins the main body of the shell (fig. 4). I have been unable to satisfy myself as to the function performed by this notch. The sense tentacles on the mantle margin opposite the notch are somewhat longer than those adjacent, but I

have been unable to determine that they have a special function or that they are specially advantageously placed.

The outer surfaces of the valves (figs. 1 to 4), are marked by fine ridges and grooves that radiate from the beaks to the margin, and by rather prominent lines of growth that run out along the hinge line. Not all of the radial markings start from the beak but new ones are added at intervals so that the number remains approximately from 30 to 35 per inch on any portion of the surface. The lines generally have a somewhat wavy or zigzag course. Those on the upper, left valve, are more rounded and prominent than those on the under, probably because of the difference in wear in the two cases. The wear is further indicated by the fact that the markings may be nearly or quite obliterated on the most convex portion of the lower valve.

The lines of growth are visible as very fine lines all over the surface, but are much more prominent in some places than others. The larger ones may appear as ridges, which would seem to indicate that marginal growth occasionally stops as the shell thickens along a line, or they may appear as a series of rather jagged depressions that indicate where the old margins have been broken. These latter markings are rather more abundant on the lower than on the upper valve. Their relative abundance compared to the shells of other lamellibranchs is easily accounted for by the use to which the shell is put in swimming and as the upper valve usually extends over the margin of the lower (fig. 19) each blow when the valves are clapped together would be directed by the more solid inner portion of the upper valve directly onto the margin of the lower valve, thus being more likely to break off small bits from it.

The outer surface of the shell, especially of the upper valve, seems to be more than ordinarily subject to the attacks of the boring sponge, Cliona sulphurea, which frequently riddles the shell so that hardly a trace of the original surface is left (fig. 3). The reasons for the attacks on this shell more than on the shells of other mollusks found in the region is probably due to the fact that this animal does not burrow and that the shell is not provided with anything like an adequate cuticle, a layer that could not be formed because the enlarged margin of the mantle must necessarily be withdrawn far into the shell whenever the valves

are brought together. The borings of the sponge frequently weaken the shells decidedly and it is not uncommon to find borings that come so near the inner surface that light may readily be seen through them, but I have never found actual perforation of the shells. It seems probable that the secretion from the sponge that acts in dissolving the shell soaks through the shell sufficiently to stimulate the mantle to renewed secretion of shell substance before the perforations are actually complete. This is indicated by the fact that shells that are badly attacked are quite universally thicker in these places than those that are not so badly attacked, and that their inner surfaces are likely to be roughened (fig. 7). The meaning of the roughened appearance is especially striking if shells that are bored only in patches are examined. In such cases the end of each of the deep burrows is marked on the inner surface of the shell by a rounded elevation, each of which reminds one at first sight of a minute pearl that has become fastened to the shell, and partially covered up by later secretions of nacre.

The markings on the inner surface of the shell are much more distinct in some individuals than in others and they differ somewhat on the two valves.

The adductor muscle scar is quite large and fairly distinct, and is placed somewhere near the center of the shell, a little nearer the posterior than the anterior border. The scar is much larger on the left (fig. 5), than in the right valve (fig. 6), where it is distinctly double, consisting of a large rounded anterior portion, (pas.) and a small somewhat crescent shaped posterior portion (pas'.). The scars usually form depressions, but sometimes elevatons, on the inner surface of the shell, and are more or less distinctly marked by lines that indicate the larger bundles into which the muscle is divided.

The foot retractor muscle is attached to the left valve of the shell along the dorsal border of the adductor muscle, just anterior to the upper end of the posterior crescent shaped portion, and the scar is not distinguishable from the scar of the adductor muscle.

The mantle is very firmly attached to each valve along a rather broad and indistinct pallial line, (pl.) that is very far removed from the margin of the shell. The muscles attached along the

greater portion of this line radiate toward the free edge of the mantle. The margin of the mantle is also well supplied with circular muscles that, near the hinge line, are collected into large bundles and attached to the shell, (aps. and pps.). The scars on the shell caused by the attachment of these muscles are somewhat larger and more distinct posteriorly than anteriorly.

Immediately beneath the scars of the adductor muscle there is frequently to be seen an indistinct line that marks the attachment of the muscles by which the gills are elevated (fig. 7, sms.)

The inner surface of the shell is sometimes quite smooth, in which case fine radiating lines, possibly corresponding to the radial pallial muscles, may sometimes be seen running from the pallial line toward the free margins of the shell. It more frequently happens, however, that the inner surface of the shell is roughened. These roughenings are no doubt always due to the secretion of nacre caused by irritation, probably sometimes due to the boring sponges before mentioned, but also to other causes. Not infrequently the inner surface of the shell is marked by minute elevations each of which has a dark spot at its tip. In such shells it has frequently been noticed that the mantle is spotted as if diseased but whether the spots are due to parasites as was determined by Jameson (13) has not been determined, neither has the relationship of the spots on the mantle to the spots on the shell been determind.

Pearls are sometimes very numerous, several dozen having been taken from a single shell. When these become attached to the inner surface of the shell, they give it a very rough appearance.

This inner surface of the shell is further frequently marked by dark streaks and blotches that are usually caused by worms and other marine animals that inhabit the holes that have been formed by the boring sponges.

The structure of the shell does not correspond to the structure of a large majority of mollusk shells. Most shells are composed of a nacreous inside layer, a prismatic middle layer and an outside cuticle. In this form, and this holds true for the other scallops that I have examined, only the nacreous layer seems to be present. I have not been able to find a trace of either of the other layers in the sections that I have made, but the shell is so

brittle that it is hard to grind satisfactory sections. A cuticular gland is present along the margins of the mantle (fig. 26, cgl.), and in this gland fragments of a weak layer that no doubt is cuticle is present but the frequent removal of the mantle margin far into the interior of the shell would seriously interfere with the formation of a continuous cuticle. As might be expected in an animal where so large a portion of the mantle is movable, the nacre is not formed of such uniform delicate layers as are found in some shells. Layers are present but the carbonate of lime seems to have become partly crystalized and the layers interrupted in places.

The shell material may vary in color considerably in individuals, or in the same individual, but this seems to be a variation in the nacre and not caused by the presence of other layers. The variation is especially well marked in the smaller more southern scallop, Pecten irradians, where the outer portions of each of the ridges that are so prominent in this species is deeply colored while the inner surface of the ridges and the portions forming the valleys between the ridges are white. It all seems to correspond in structure to nacre however.

The valves are attached to each other along the hinge line by a very weak ligament which represents a modification of a cuticle that serves simply to hold the two valves together along this line. Near the middle of the hinge line, just beneath the beaks, there is in each valve a deep and broad somewhat triangular depression that in old shells opens quite broadly on the hinge line. This depression, (fig. 5, cp.) forms the cartilage pit, into which is set the end of an elastic pad, the so-called cartilage, (fig. 10, c.) which is a modification of the ligament.

When the adductor muscle contracts and the valves are drawn together, this pad of cartilage is compressed and serves, when the muscle relaxes, to separate the valves again. The cartilage is composed of the same material as the enlarged elastic ligaments of such forms as the fresh-water mussels, and no doubt they have had a common origin. They both serve to open the shell by their elasticity, in the one case by expanding after being compressed and in the other by contracting after being stretched.

The inside of each valve of the shell is lined by a thin fold of tissue, a mantle lobe (fig. 10, m.). The mantle lobes are united to each other along the hinge line and anteriorly and posteriorly for a space that practically corresponds to the width of the ears of the shell.

With the exception of the free borders of the mantle, each lobe consists of a very thin membrane that is closely applied to the inner surface of the shell which it entirely covers in the living extended animal. In specimens that have been disturbed so the shell valves are closed together, the margins of the mantle lobes are drawn far back into the shell so there may be a strip of three-quarters of an inch or more of the inner border of each shell valve that is left uncovered. This retraction of the mantle is necessary in order that the thickened and highly modified margins of the mantle may not be injured by the closing of the shell.

Each mantle lobe is free from the rest of the body except where it covers and is fused with the adductor muscle and digestive gland, where it is joined by the posterior border of each of the outer labial palps, and where it is joined by the membranes that support the gills.

The formation of the shell is due entirely to the secretion of materials by the mantle. The nacre, which forms the inner surface and most, if not the entire thickness of the shell is secreted by the whole of the applied surface of the mantle and in healthy perfect shells is quite smooth and white. As it is constantly being added to, it is thicker in old than in young shells and in the older part of the shell, toward the middle of the hinge than elsewhere. Certain portions of the mantle, as that along the margins between the pallial lines and the free borders, and in the region of the hinge line and wings, are more active than others in secreting nacre. In these regions the epithelium on the shell side of the mantle is composed of especially large apparently actively secreting cells, while the remainder of the surface is composed of small less active cells. This arrangement is in accord with the especially thick portion of the shell along the hinge line including the ears, and with the

fact that the margins of the valves are thicker than would otherwise be expected.

If a prismatic layer is present it must be secreted by the extreme margin of the mantle but there is nothing in the appearance of the epethelium of this region that would indicate that it has a different function than that a little further removed from the margin.

A gland for the formation of the cuticle occupies a grove along the margin of the mantle, (fig. 26, cgl.) and fragments of a thin and apparently not very tough cuticle may nearly always be seen in it attached at the inner end of the gland to the epethelium that secretes it, but the withdrawal of the mantle margins far into the shell when the shell is closed must interfere with the formation of anything like a continuous cuticle. The ligament and cartilage are both present, although the former is quite thin, and may be looked upon as modifications of the cuticle. They are secreted by adjacent portions of the mantle.

The free margin of each lobe is very muscular, is abundantly supplied with organs in the form of tactile tentacles and eyes, and is provided with a large flattened ridge that is turned away from the shell valve on which the mantle lobe rests (figs. 10, 19, 20, and 26). The ridges on the two mantle lobes may be brought into contact with each other at any or all points along the margin, when the shell valves are slightly separated and thus regulate the currents of water formed by the cilia on the gills, or in swimming.

The muscles of the mantle, (figs. 16 and 26) may be grouped as the radial pallial, which are attached to the shell at the pallial lines and radiate out toward the margins, the circular pallial which are very strong, attached to the shell valves near the hinge line and run along the borders of the mantle, the muscles of the pallial ridge that are largely circular but contain also radial muscles connected with the radial muscles that have been referred to, and the suspensory muscles of the gills which are really continuation of a fold of the mantle and are attached to the shell valves between the pallial scars and the adductor muscle scars. All but the last group of these muscles, which will be described in connection with the gills, are confined to the borders of the mantle and, together with the infolded ridge, sense organs

and pigmentation of this region, form a thickened portion that is very striking in appearance when compared with similar parts of most other forms.

The radial muscles are much longer and more powerful in the region opposite the hinge line than elsewhere and have for their chief function the withdrawal of the mantle margins into the shell in order that the margins may not be injured in closing the shell, which is closed both rapidly and powerfully, especially when the animal is swimming. The radial muscles of the infolded ridge are continuous with these muscles and serve to contract the width of the ridge or to extend the ridge out in the same plane with the rest of the mantle, that is to extend it out of the shell. This is no doubt done in conjunction with relaxing the circular muscles of the ridge, and extending the margin by blood pressure.

The circular pallial muscles of each mantle lobe form a very strong band that is attached to the corresponding shell valve anteriorly and posteriorly just beneath the ridge along the hinge line, at the dorsal ends of the pallial lines. They are spread out between the attachment of the radial muscles and the margins of the mantle lobes but are strongest some distance away from the attachment of the radial muscles and they nearly or quite disappear before the pallial nerve is reached. They serve as constrictors that are important in withdrawing the margins into the shell. In this they act in conjunction with the radial muscles. Their attachment to the shell along the dorsal limits of the pallial line suggests that they may be regarded as extended, modified radial muscles of this region of the mantle.

The circular muscles of the infolded ridges are connected with this band especially near the hinge line. Here the circular muscles become continuous with the other circular muscles. This leaves the dorsal inch and a half or two inches of the ridges both anteriorly and posteriorly without well developed circular muscles. The radial muscles of the ridges of these regions are also poorly developed so there is but little independent movement of the ridges near the hinge line. It is interesting to notice further that the tentacles on the ridges are not developed in this region and that with the exception of the extreme dorsal margin, the parts covered by the ears, the eyes are absent or

very few in number. The circular muscles of the ridges are important in adjusting the positions of the ridges to each other and thus in regulating the currents of water in respiration and feeding, and in swimming.

The sense organs of the mantle are of two distinct kinds, tactile tentacles and eyes. The tentacles are distributed in two bands along the margin of each lobe (figs. 10 and 20). The largest forms a broad band, several tentacles deep that runs along the inner face of the margin of each lobe slightly removed from the extreme edge, about where the base of the infolded ridge joins the lobe. The tentacles in this ridge vary greatly in size, those placed farthest from the margin usually being the largest and those next to the free margins being smallest (fig. 26). Along the borders of the ears of the shell the tentacles are somewhat longer and more slender than elsewhere, and they are perhaps longest near the notch at the base of the anterior ear. A large individual may possess several thousand tentacles for there are from 75 to 100 on an inch of border.

The other band runs along the face of the ridge near its free border. In appearance these tentacles correspond to those of the other band, but they are not nearly as numerous and are not as large as the largest in the other band. They are most abundant in the portion farthest removed from the hinge line and are not found on the portions adjacent to the hinge.

All of the tentacles of both bands are capable of being greatly lengthened so they sometimes form a fringe along the border, an inch or more in length. When the animal is disturbed they are immediately withdrawn and form conical projections hardly more than a sixteenth of an inch in length for the largest.

The structure of the tentacles will be considered under the head of sense organs.

The eyes are placed along the margin of the larger band of tentacles, on the side that is turned away from the free border of the lobe of the mantle. They form a single scattered row in which they are set at irregular intervals but fairly close together. They are most abundant along the border farthest from the hinge and are absent or very few in number for an interval near the ears of the shell both anteriorly and posteriorly. In the

space covered by the ears a few eyes are present. In all there are frequently as many as one hundred on each of the lobes of the mantle. Their size even in old individuals is noticeably unequal and they are not arranged in any order of size. As there are many more eyes in large than in small individuals, new ones must be added during the growth of the animal and their size may be an indication of their age. If this is true, new eyes are not added in accordance with any plan but make their appearance as spaces for them occur. The outer ends of the stalks on which the eyes are set are deeply pigmented with black or brown pigment, and the eyes themselves are blue and exceedingly brilliant. The structure of the eyes will be considered under the head of sense organs.

The mantle margins, including the infolded ridges and tentacles, are usually highly pigmented. Yellow and brown, either light or so dark as to approach black, are conspicuous in this pigmentation. Sometimes the margins are nearly of the same color throughout their extent but they are frequently blotched with different colors and with different shades of the same color arranged in irregular patterns so that with the infolded ridges, the tentacles and the brilliant eyes, the margins make very striking objects. What purpose the brilliant pigmentation may serve I cannot say. Perhaps they are not as conspicuous among the yellow incrusting sponges and the other variously colored incrusting growths among which they live. Living in deep water as the animal does, these are matters that are not easily studied.

The distribution of nerves and blood vessels in the mantle will be described in the general consideration of the nervous system and the vascular system of the animal.

VISCERAL MASS AND FOOT.

It will hardly be necessary to describe the general shape and positions of these portions of the animal as reference to figures will make the relation of parts much clearer than description (figs. 11 and 12). It will be noticed that the portion containing the digestive gland or liver, and the reproductive portion of the viscera are not broadly connected, and that the foot is placed anterior to the heart and ventral to the connecting portion.

This arrangement is such that the large adductor muscle is pretty well inclosed, there being only a small postero-ventral portion of the muscle that is not surrounded by the other organs.

The portion near the hinge consists almost entirely of the digestive gland, commonly called the liver, with the œsophagus, stomach and first part of the intestine inclosed in it. During the season of reproduction, a thin layer of gonads extends over its surfaces laterally as well as anteriorly and posteriorly. The portion ventral to the foot consists almost entirely of the gonads with the coils of the intestines running through them. The foot is largely muscle with a rather extensive byssal gland inclosed in it. The liver region extends from valve to valve of the shell and is covered closely with a very thin portion of the mantle. The reproductive portion and foot are comparatively narrow and are suspended between the gills, being supported in large part by the adductor muscle. These portions do not occupy a position midway between the two valves but are nearer the right than the left valve.

The foot is a comparatively slender, roughly cylindrical organ somewhat larger where it is attached to the body than elsewhere, cleft at its free end, so it may be spread to form a "sole" as in Nucula and Yoldia, and showing the large opening of the byssal gland to the right of the middle line, on the ventral surface somewhat behind the sole (fig. 8).

The foot has lost its symmetry, being twisted so the ventral surface is directed somewhat toward the right valve. It seems to be in a large measure a degenerate organ that is practically of no service as an organ of locomotion. The animal depends upon swimming by clapping the shell valves together to change position. The foot may however be greatly extended and thrust between the valves of the shell. When protruded it leaves the shell just ventral to the notch at the base of the anterior ear, and may be moved from place to place. The flaps on the sides of the foot are moveable and are frequently separated somewhat but there is no such active movement as in Yoldia (6) or other forms with this type of foot, with which I am acquainted. In the species under consideration I have never seen the foot protrude far out of the shell and have never seen the animal attach itself with a byssus.

Individuals of the smaller species, Pectens irradians, do attach themselves with a byssus and I have no reason to doubt that individuals of this species attach themselves. An individual of Pecten irradians placed in a glass dish of sea water will sometimes protrude its foot from the shell, apply it closely to the bottom of the dish and after a short time slowly withdraw it, leaving a rather broad band of slightly yellowish material attached to the glass and connected with the foot at the byssal gland. This is not composed of small tough threads as in the mussels Mytilus and Modiola, but it may be sufficiently tough to support the weight of the animal if, after a few minutes, the dish is carefully turned over. The animals seem never to remain attached for long periods, but after a few hours at most the attachment is dropped at the byssal gland. Whether this is passive or due to a sudden strain caused by forcing strong currents of water from the shell as in swimming has not been observed.

As in other lamellibranchs the foot is largely composed of crossing muscle fibres that by individual or combined action may press upon blood that may be confined in a rather large blood space in the foot and so cause the elastic foot to be extended. The foot is attached to the shell by a single retractor muscle which runs along the dorsal portion of the foot posteriorly, dorsal to the posterior adductor muscle, to be inserted on the left shell valve at about the point where the adductor muscle is separated into two parts (fig. 10, fm.). This muscle extends along the dorsal border of the foot and is about equally in evidence on its right and left sides. Above the opening of the byssal gland, which lies somewhat to the right of the median line on the ventral side, the muscle loses its individuality and becomes merged with the general foot muscles. It leaves the foot along the median line flattens a little and gradually runs over on the left side to be attached to the left shell valve. Why the right muscle should have degenerated is not clear but the position, attached to the left shell valve, which is uppermost, gives the muscle a straighter pull when the foot is attached to the bottom by the byssus than would be the case if the right muscle had persisted instead.

The byssal gland is quite extensive and not only permeates a considerable portion of the foot but extends some distance dorsally and posteriorly ventral to the retractor muscle of the foot. It is a racemose gland of the usual character.

ALIMENTARY CANAL.

The œsophagus is rather short and extends from the mouth, which lies beneath the anterior protruding portion of the liver, to the antero-dorsal portion of the stomach. The stomach fig. 12, s.), is fairly large and receives two large ducts from the liver which surrounds it. The openings of these ducts into the stomach are so large as to form two latteral diverticula of the stomach into which the smaller ducts from the liver empty. The portion of the alimentary canal that extends from the rounded stomach to near the posterior portion of the body is of greater diameter than the remaining portion and resembles in microscopic appearance the stomach rather than the intestine. A portion of the lining epithelium of this and of the lower end of the stomach resembles that usually concerned in the formation of a crystalline style. While a definite, well formed rod-like style, such as is so well formed in the soft clam, Mya, is not present, a large quantity of mucous is secreted. This mucous entangles the food that is swallowed and very likely performs the same function that is performed by the dissolving of the crystalline style which Kellogg (14) with much reason thinks may be to keep the cilia of the alimentary canal from forcing the food through the canal before it has had time to digest.

The remaining portion of the alimentary canal, is of about even diameter throughout its length and is lined by epithelium of the character ordinarily found in this portion in lamellibranchs. It is a ciliated epithelium, the cells of which stain deeply and probably have some secretory function. Undoubtedly the chief reason for having the canal so elongated is to give time and surface for absorbing digested food.

The position of the loops of the intestine are shown in figure 12, i, and needs no special description. It is worth noticing that the loops are practically in the same position in Pecten irradians, the only other species of scallop that I have examined. In the figure given by Pelseneer, which is copied in Parker &

Haswell's Text-Book of Zoology, page 648, the reverse loop of the intestine in the posterior portion of the visceral mass is not given. This may not be present in the species figured, but it seems quite possible that it might have been overlooked in dissections as the backward turn is so abrupt and takes place so near the other portion of the intestine. After running dorsally nearly to the hinge line, the intestine bends rather abruptly postero-ventrally, perforates the ventricle of the heart, and terminates posterior to the adductor muscle. The last inch or more of the intestine protrudes from the general body and ends in a dorsal turn that directs the fæces toward the edge of the shell in the same direction that is taken by the excurrent stream of water that is coming from the gills. It is important that the fæces should be voided, as they are, where they may be promptly removed by the current of water coming from the gills.

Throughout the length of the alimentary canal its epithelium is ciliated and movements of its contents are dependent upon the action of the cilia. The general movements caused by the muscles of the body wall may have some effect, but there is no special muscular provision to aid in the movement of ingested material.

The muscles covering the pericardium are continued down over the otherwise free extremity of the intestine and may have the action of a sphincter but in the living individuals and in the sections examined, the lumen of the intestine seems to be quite as unobstructed in this region as in other regions.

LABIAL PALPS.

These organs are essentially lips and have for their chief, if not their only, function the conducting of food into the mouth. There is as in other forms a pair of palps on each side of the body. The palps on one side of the body are connected with those of the other above and below the mouth so they resemble large drawn out lips with the upper lip of each side covering the under lip of the corresponding side so their inner surfaces, that is the surfaces continuous with the epithenium of the œsophagus, are applied to each other. In many kinds of lamellibranchs the palps consist of inconspicuous smooth flaps of tissue that have their inner or opposed surfaces thrown into series of ridges and

grooves which are densely ciliated. In this form, (figs. 10 and 12, lp.) the portions of the palps that lie along the sides of the body are of this character but the portions above and below the mouth are ruffled so they form a large conspicuous mass that entirely conceals the mouth. What purpose is served by this ruffled portion that would not be served as well by the simpler arrangement has not been determined.

Both palps are free only along their ventral borders. The outer palps, which correspond to the upper lips, are united to the body wall above the mouth and along their dorsal borders. The inner palps, which correspond to the lower lip, are united to the body wall below the mouth along their dorsal borders and have their inner surfaces continuous with the inner surfaces of the outer palps. Their posterior borders, which are not as extensive as the corresponding posterior borders of the outer palps are united to the body wall.

Food from the gills passed between the palps is conducted by the cilia covering their opposing surfaces to the corners of the mouth, of which the grooves formed by the union of the dorsal borders of the outer and inner palps are continuations.

GILLS.

As in most lamellibranchs the gills (figs. 11, 12 and 19), are four in number, there being two on each side of the body. Each of these gills appears as a thin and delicate striated membrane that runs from near the mouth, around the ventral side of the adductor muscle to and a little beyond the anal opening. The gills are very similar in appearance, pointed anteriorly and posteriorly and marked by distinct striations that radiate from their lines of attachment near the adductor muscle, toward their free borders. With proper illumination very fine striations may be seen crossing these at right angles.

Each gill consists of two thin membranes, called lamellæ (figs. 17, 18 and 19), that lie very close together and are attached to each other at intervals corresponding to the radial striations of the gill. Each pair of gills is suspended by a muscular membrane (figs. 19 and 20, sm.), most of the muscles of which are inserted on the corresponding shell valve near the

border of the adductor muscle (fig. 7, sms.). The membrane however has the appearance of being suspended from the adductor muscle as connective tissue fibers extend along the surface of the muscle and bend it toward the visceral mass. Most of the muscles of the membrane run from the region of the adductor muscle directly toward the borders of the gills attached to it, but two distinct bands of muscles are present (fig. 18 lm.), that occupy positions along the sides of the blood space which runs along the dorsal borders of the gills and receives blood from the gills. When the gills are elevated these muscles contract and shorten the gills, at the same time throwing them into a series of plaits. Each of the gills that are attached to this membrane is attached by one lamella only. The outer gill is attached by its inner lamella and the inner gill by its outer lamella. The remaining lamellæ are free along their borders which are usually somewhat reflected.

The gills of lamellibranchs are usually attached so the dorsal borders of the outer lamellæ of the outer gills are attached to the mantle and the dorsal borders of the inner lamellæ of the inner gills are attached to the visceral mass, or behind the visceral mass, to each other. In this way the gills divide the space between the lobes of the mantle into a ventral space, the branchial chamber, into which the gills hang, and a dorsal space, the cloacal chamber, above the gills. This dorsal space is divided throughout the greater portion of its extent by the visceral mass and by the membranes that support the gills on each side, which in the scallop are muscular.

Although the gills on each side do not form the attachments described, the free edges of the gills are pushed out and make contacts that correspond with the attachments in other forms that have been described. It is important that such contacts should be made as the water that passes through the gills for purposes of respiration and feeding, in a manner to be described later, must be constantly renewed from the outside to be effective for either purpose, and if the outsides of the gills and the spaces between their lamellæ did not communicate with separate cavities, a current could not be formed. It is also important for a scallop, which swims by throwing powerful currents of water from the mantle chamber to have no permanent division between

the branchial and the cloacal chambers as the pressure of the water in the cloacal chamber caused by the rapid closing of the shell would be certain to injure the gills. At such times the gills are kept from injury by the contraction of the muscles of the interlamellar junctions, so the lamellæ of each gill are drawn together and by the contraction of the suspensory membranes of the gills which draw them away from the margins of the shell and keep them from being crushed. No doubt the arrangement of the gills in this form is to be explained by its exceptional habits.

As before stated the two lamellæ of a gill are attached to each other at intervals corresponding to the striations that run the width of the gill. These lines of attachment (fig. 17, ilj.), the interlamellar junctions, form complete partitions so the space between the lamellæ is divided into a series of tubes, the water tubes, that are closed, except for minute openings in the sides, (io.) the inhalent ostia, and where they open into the cloacal chamber. Each tube extends from the free border of the gill (figs. 18 and 20), where it is closed by the joined lamellæ, to its opening in the cloacal chamber, and is bounded by the lamellæ and by the interlamellar junctions. Of these water tubes there are several hundred in the length of each gill.

Each lamella is composed of a series of delicate filaments, (fig. 17, gf.)the gill filaments, that run the width of the gill parallel to the more prominent striations. These filaments are of two kinds, large ones concerned in the formation of the inter-lamellar junctions, and small ones. They are all connected at intervals by cross bars, (ifj.) the inter-filamentar junctions, that run at right angles to them.

The crossing bars (the filaments and the inter-filamentar junctions), leave spaces, the inhalent ostia (fig. 17, io.) between them, that are the openings that have been referred to as leading into the water tubes. The inhalent ostia are much larger and more regular in the scallop than in most other lamelli-branchs, as the lines of fusion that form the inter-filamentar junctions are not nearly as extensive as in most other forms.

Usually the filaments of one lamella are continuous with those of the other at the free margin of the gill, so it is quite possible to trace a filament from the suspensory membrane down one

lamella around the margin of the gill and up to the free border of the other lamella. Whether filaments are always continuous in this manner or not has not been determined, but in the sections that have been examined the same number of filaments are constantly present on the two sides of any given water-tube.

The filaments are very similar in size and appearance, except those that are concerned in the formation of the inter-lamellar junctions. These are many times as large as the others and differ decidedly in shape as well as structure. Those placed next to these modified filaments are somewhat larger than the remainder but they do not otherwise differ in appearance or structure. The number of filaments concerned in the formation of water tubes is not entirely constant. Nineteen of the small filaments, between the large modified filaments, is a very common number but as few as seventeen and as many as twenty-two have been noticed. No attempt has been made to determine the relative number of filaments for each water tube in different parts of the gill but the variations mentioned occur within a space of ten or a dozen tubes.

Each of the smaller filaments is composed of a layer of surface epithetium that incloses some connective tissue and a large blood space. The connective tissue is so arranged that quite universally a strand of tissue extends across the blood space (fig. 21, fs.) from one side of the filament to the other, so in cross sections of the filament the blood space appears divided into two nearly equal portions. This Kellogg (14) has quite naturally taken for a functional division that allows the blood to pass down one side of the filament and back the other. That this is not actually its function is indicated by injections of the vascular system that I have made, and by the connections of the blood spaces of the filaments to the afferent and efferent vessels of the gill. There is every indication that the blood moves in the same direction on each side of the partition, if it is a complete partition. The only reason that I can suggest to explain its constant presence is that each acts as a brace to keep the filament from swelling into a cylinder with the pressure of the blood, and so partially close and interfere with the flow of water through the inhalent ostia. That there is great need for braces of this character in filaments shaped like these, where they are not

supported along their sides by extensive inter-filamentar junctions as is commonly the case, is evident, but I have not examined other forms in which the filaments are similar, to find if similar braces exist.

The epithelial cells on the outsides of the filaments bear numerous rather short cilia (fig. 21, fc.) that have to do with moving currents over the surface of the gill. Between the filaments, but near their outer borders, the epithilial cells are modified in shape so they collectively give rise to a strong band of cilia (oc.) on each side of each filament. In transverse sections of filaments each of these bands appears as a bunch. These cilia are concerned in forcing water through the ostia and thus in creating the currents of water that furnish the food and oxygen for the animal.

The large modified filaments are roughly triangular in cross section and like the smaller filaments each has a surface layer of epithelium. The epithelium on the outer surface of the filament is thickly covered with cilia that correspond to the surface cilia of the other filaments but there are no bands of cilia along the sides. Inside the layer of epithelium is a pair of chitinous rods (fig. 21, cr.) that run nearly to the free margin of the gill. These rods are elastic and quite stiff and serve to keep the gill in shape. Similar rods are present in each filament in many forms but there seems to be no sign of them in the scallop in any but these enlarged filaments. Considerable connective tissue and well developed bands of muscle (mf.) are present, that together cut up the large blood space (bv'. into a number of small ones which are, however, connected with each other at frequent intervals, so they may be regarded collectively as one blood space.

With corn starch injecting mass these spaces will frequently inject for half the width of the gill. With gelatine injecting mass it is quite possible to inject the vessels of the smaller filaments as well and get the connection through the interfilamentar junctions. In these injections it frequently happens that a filament will be injected for only a portion of its length and in such cases the whole cavity of the filament is filled as far as the injection extends. This indicates that the apparent partition is not functional as a division between vessels.

The muscles of the large filaments are for the most part continuous with the muscular suspensory membranes. Fibers extend through the inter-lamellar junctions to the free lamella and serve to draw the lamellæ together. Other fibers extend through the inter-filamentar junctions and serve to draw the filaments together and so shorten the gill. A nerve (fig. 21, n.) is frequently present near the inner border (the border away from the outer surface of the gill) of the filament. How universally this is true has not been determined but I have frequently been unable to discover such nerves. Again each of a series of filaments may have its nerve. Branches from these nerves have been traced into the inter-filamentar junctions and presumably give out branches in turn to the filaments. They probably also control the muscles of the larger filaments, inter-lamellar junctions and inter-filamentar junctions. The inter-filamentar muscles are especially active in gills hat have been cut from the animal, and keep the gills in almost constant movement, folding the lamellæ and allowing them to straighten, as they contract and relax in different portions. The large filaments of one lamella are united to the large filaments of the other lamella by rather thin membranes, the inter-lamellar junctions (figs. 17 and 18, ilj.) that are thickened along their free borders, where a large blood vessel is present. They are likewise more extensive along this border so the lamellæ may be separated quite a distance along the upper border of the gill. The shape of the membranes is such as to allow greater separation than would be the case if the attachment extended straight across from one lamella to the other. The bend that is made, allows great freedom of movement to the free edge of the lamella, which may thus be separated from the attached border of the other lamella of the gill for a space of half an inch or more.

The inter-filamentar junctions (fig. 18, ifj.) are much heavier along the upper margins of the lamellæ than toward the free edge of the gill. These junctions are very muscular, and are much heavier near the large filaments than they are toward the middle of the water tube (fig. 17, ifj.). They join the filaments to each other and extend into the cavity of the water tubes as rather prominent ridges. Each inter-filamentar junction con-

tains a rather large blood vessel that is connected with the vessels of the large and the small filaments, and thus serves to distribute blood either from or to the large vessels of the large filaments, which are connected in their turn to the vessels that supply blood to or take blood from the gills.

As the free edges of the gills are approached the inter-filamentar junctions become less and less prominent until, near the margin, the filaments near the middle of the water tubes are connected only by bunches of cilia like those in the mussel, Mytilus, and some other forms. That the junctions of this region should be less prominent is what might be expected, for the margins of the gills, after the gills have become sufficiently developed to show adult structure, are the growing and consequently the youngest portions. That the filaments should at first be connected by cilia only, may be looked upon as an indication of past history. The scallops presumably have had ancestors in which the gill filaments were united by cilia only.

Inasmuch as the gills are respiratory orgens, the arrangement of the blood spaces in them is of more than ordinary interest.

Two blood vessels are present in each of the suspensory membranes of the gills, near the borders of the gills that it supports. These vessels follow along the borders of the gills from near their anterior to their posterior ends. One, the dorsal, that is the one farthest away from the gills, supplies both of the gills with blood, the other, the ventral, which is very near the borders of the gills, receives the blood that is returned from both of the gills. The blood enters each gill by branches from the supplying vessel (figs. 17 and 18, ba'.) that run along the upper borders of the inter-lamellar junctions to the edge of the free lamella. Here they enter the large modified filaments of this lamella (fig. 17, ba".) and are continued down to the margin of the gill, giving off vessels to each of the inter-filamentar junctions except those near the margin of the gill, which consist of cilia only and are accordingly not vascular.

Through the inter-filamentar junctions the blood is supplied to the small filaments, so the blood vessels become a net work that corresponds to the structure of the gill itself. The blood makes its way around the margin of the gill, through somewhat broken passages to the other lamella. This takes place all along

the margin in both large and small filaments. The vessels in the other lamella are similar to those already described, the blood being collected on this side into the vessels of the large filaments (fig. 17, bv'.), and finally poured into the vessel at the bases of the gills, which conducts the blood back to the heart (fig. 18, bv.).

It is quite possible to make out all of the connections described, in sections of the gills but the arrangement of vessels has been further demonstrated by injections of the gills with starch and with gelatine injecting masses. This can readily be accomplished through the supplying and receiving vessels of the gill with a hypodermic syringe. The animals are large and the vessels are fairly distinct so with a little practice it is quite easy to make successful injections. With a starch mass the vessels may readily be injected different colors as the mass is too coarse to pass out into the smaller vessels and complete the circuit. By this method it was easy to determine that the blood passing to the gill all passed along the borders of the inter-lamellar junctions to the free lamella and that all of the blood entering the vessel that carries the blood away from the gill comes from the attached lamella.

The general relation of the blood spaces of the gills to the rest of the circulatory system will be discussed under the head of the circulatory system.

The movement of water for respiration and feeding is dependent entirely upon the bands of cilia on the sides of the filaments. These, acting like so many small paddles, force the water through the inhalent ostia into the water tubes, thus driving the water along the water tubes into the space above the gills that corresponds to a cloacal chamber, and so out of the shell along the margin posterior to the adductor muscle and dorsal to the gills. The current of water which enters to take the place of that driven out is taken in anywhere along the ventral and anterior borders of the animal. By changing the position of the margins of the mantle so access is given at one place and denied at another, it is possible for the animal to vary the places where water is admitted and ejected. Whether this serves any definite purpose or is more by way of accident caused by performing other functions of the body, is not known, but powdered carmine

allowed to settle in the water past the margins of the shell of an extended individual will show that such variations in the currents do occur.

This current of water not only supplies the means of respiration, allowing the blood that is passing through the gills to become charged with oxygen and to rid itself of carbon dioxide, but it serves to supply the animals with food.

The food for the most part consists of microscopic plants which are strained out of the water that passes through the inhalent ostia. These are passed along the surfaces of the gills by the cilia that cover the surfaces of the filaments, to their free margins and along the margins to the anterior ends of the gills. Here they are passed between the labial palps which inclose the anterior ends of the gills, and so on into the mouth.

Attention has not been given to the action of the feeding cilia in this form, but Kellogg (15) and Stenta (31) have found that the action is apparently under control in many forms, so food that is passed over the surface of the gills may be carried to the palps or may be passed onto definite tracts of cilia on the mantle that carry it away and finally eject it from the mantle chamber. It would thus seem that while the cilia on a gill are active, food is being strained out but that the animal may or may not eat the food gathered.

The ability to accept or to reject solid material that is brought to the gills in the current of water that is formed by the cilia on the gills is indicated by examining the stomach contents, as well as by the observations made by Kellogg and Stenta. The study of the food that is in the stomach shows that there has actually been selection of materials and that the ability to reject is not simply to allow the animal to continue respiration without feeding, for there are many forms of diatoms that are abundant in the water in which the animal lives that are not present in its stomach. The observations of Grave (8) on the food of the oyster indicate how great this selection may be and no one who has given any attention to the stomach contents of lamellibranchs will doubt that food selection is common among members of the group. No observations have been made on the speed with which food is gathered by scallops but as the method of feeding is so similar for most lamellibranchs the observations made by

Grave (8) on the oyster are of great interest. By a series of careful experiments he determined that oysters that had been kept out of water and in filtered water until most of the food had been digested or passed through the alimentary canal, collected on an average, upon being returned to the bottom from which they were taken, " 385 diatoms during the first hour, 550 during the second, 1,406 during the third and 4,301 during the fourth. This increasing rate of feeding is probably due to the gradual recovery on the part of the oysters from the shock of their unusual treatment in the laboratory. The rate at which feeding took place during the fourth hour is probably nearer the rate at which it occurs with oysters living undisturbed on the beds."

From these and other observations Grave draws conclusions regarding the length of time that an oyster must feed and the amount of food that water must contain, in order that oysters shall get proper food supply, that are open to criticism. He says, " The work on the food resources of Newport river show the average number of diatoms per liter (or about a quart) available to oysters on the natural beds, during the summers of 1900, 1901 and 1902 to be 23,432, and that the oysters of salable size examined during this time contained, on an average, 11,453 diatoms. If the usual rate of feeding under natural conditions is near the figure obtained from the above experiment, 4,301 diatoms per hour, then three hours is ample feeding time for an oyster; and taking 23,432 as the average amount of food contained in a liter of water over the natural oyster ground, it follows that in collecting its daily meal (11,453 diatoms) an oyster must filter altogether about 500 cc., or 16 oz. of water, and that about 167 cc., or 5⅓ oz., are filtered per hour." The error is in taking 11,453 diatoms, the average number to be found in an oyster's stomach at one time, as the average daily meal. This does not take into account the rate of digestion and accordingly the number that actually pass into the alimentary canal in a day is an unknown quantity. The observations indicate, however, that the number of diatoms used by an oyster is enormous and that the part taken by lamellibranchs in converting this great wealth of food material into a form that is available for the higher animals is very considerable. (See Brooks, 3.)

The muscles of each of the organs are best described in connection with the structure of the organ concerned. As the muscle that functions in closing the shell is the only one that would not naturally receive attention in describing the organs, it will be necessary here to describe in detail only the adductor muscle.

There is but one adductor muscle in the adult scallop and this corresponds to the posterior muscle of those forms that possess two muscles. In the very young scallop the anterior adductor muscle is present (fig. 35, aam.) and for a time is the only functional one, but the posterior muscle soon makes its appearance. At what stage of development the anterior adductor muscle is lost has not been determined but a scallop a centimetre (half an inch) in diameter shows no indication of such a muscle.

In the adult scallop the adductor muscle has a greater area of attachment on the left, upper, valve than on the right, and the scar on the shell is comparatively smooth and indistinctly bounded. Usually there are some markings indicating the division of the muscle into bundles but they are not nearly as prominent as on the other valve.

The muscle is quite definitely divided into two portions. An anterior large rounded portion (fig. 10, pa.) and a posterior somewhat crescent shaped portion (pa'.) that is applied on its concave side to the anterior portion. The left end of the posterior portion is a somewhat narrower and longer crescent than the right end and is applied much more closely to the anterior portion of the muscle than at the right end (figs. 9 and 16). Where the muscle is attached to the right shell valve the separation of the anterior and posterior portions is marked by a deep cleft on the ventral side of the muscle. This cleft extends along the ventral side of the muscle for nearly half the length of the muscle where it becomes a very distinct line that may readily be followed to the other end of the muscle. The two portions of the muscle differ in color, the posterior portion being darker, and their physiology is quite different. The large anterior portion may be entirely severed and the posterior will close the shell with nearly as great rapidity as was the case before the muscle was injured, but if the posterior portion

is severed and the anterior portion is left intact, the animal will not close its shell. If the shell valves are pressed together the muscle will not hold them, but they separate immediately when they are released. The meaning of this is not clear. I feel sure that it is not due to severing any nerve as the muscle has been carefully scraped from the shell with the same results. That there is some explanation that investigation will reveal seems likely. My own work has for the most part been carried on at some distance from the seashore, and the opportunity to investigate the action of the muscle has not yet presented itself.

Other prominent muscles of the body beside the usual interlacing muscles of the body wall are the radial and circular muscles of the margins of the mantle (fig. 16, rpm. and cpm.) the muscles of the suspensory membranes of the gills (fig. 20, sm.) and the retractor muscle of the foot (fig. 10, fm.) which is here confined to the left side. All of these are described in connection with the organs with which they are associated.

EXCRETORY ORGANS.

These organs lie just anterior to the adductor muscle, against which they are flattened, between the visceral mass and the suspensory membranes of the gills (figs. 12 and 20, e.). Each organ forms an elongated sac like body that runs from the extreme latteral prolongations of the pericardium ventrally, around the adductor muscle, and opens into the mantle chamber, above the gills and about one-third of the diameter of the adductor muscle from its ventral margin. The openings of the kidneys into the mantle chamber are large, slit like, and guarded by somewhat thickened lips. Not uncommonly the excretory organs of lamellibranchs consist of long coiled tubes, each organ being a single tube which may be nearly or quite cylindrical and of nearly even diameter, or the tube may be greatly sacculated or have certain enlargements. Such long coiled tubes strongly suggest nephridia, and they may be looked upon as modifications of this structure. Not uncommonly the organ is divided into a glandular and a non-glandular portion as in the fresh-water muscle, but it is usually coiled to the extent of possessing at least one loop.

In the scallop, however, the organ is of a calibre that suggests a sac more than a tube, that curves only to follow the curvature of the muscle and opens at one end by a rather broad opening into the pericardial cavity and at the other, by the slit like opening already described, into the mantle chamber. The pericardial opening of the right organ is a little more dorsal and a little nearer the mantle than the other. This seems to be caused by the shape of the adductor muscle which spreads out near its attachment to the left valve so the left excretory organ is forced in toward the median line of the body.

In structure the excretory organs are practically racemose glands. The pockets that are frequently found in the walls of the nephridia of other forms are here greatly extended and branched. The thick walls of the organs allow this without causing a roughened exterior. There is no division of the organ into glandular and non-glandular portions but it is glandular throughout.

The excretory organs are joined by the genital ducts near their inner, pericardial ends. The relationship of the two is further described in connection with the genital organs.

GENITAL ORGANS.

These organs occupy the greater part of the portion that has been called the visceral mass (fig. 12, vm.).

In this species of scallop the sexes are separate and may easily be distinguished by the color of the sexual products which give the color to the parts of the body containing them. In the female the color is bright salmon pink to dull pink, apparently differing with the number of eggs and possibly also with the maturity of the eggs. In the male the color is white or with a tinge of yellow. Pecten irradians is hermaphroditic, with the male portions of the organ dorsal, that is, near the foot, and the female portion in the remaining large, ventral and posterior portions of the visceral mass. The male portion is here white, the female brownish yellow or orange. Both kinds of sexual products are matured at the same time and there is considerable reason to believe that individual fertilization may be and possibly frequently is accomplished.

In the giant scallop the distribution of the gential organs is the same in both sexes. The organs occupy nearly the whole of that portion of the body that lies beneath the foot that is not occupied by the alimentary canal, and extend up dorsal to the foot so as to form a thin layer over the surface of a portion of the liver. When the organs are gorged with their products the portions of the body that contain them are plump and comparatively large. When spawning has been completed they are shriveled and small. In the adult there is no apparent separation into a pair of organs farther than by the possession of a pair of ducts. These are not very conspicuous and enter the kidneys of the respective sides near their dorsal ends. From this point out, the sexual products traverse the lumen of the kidney, so they are finally expelled into the water through the external opening of the kidney.

The products are expelled from the openings of the kidneys in streams. The animal occasionally flaps its valves together during the process so the products are thrown out of the shell and dispersed in the water. For the most part the animal lies with the valves separated and is rather indifferent to outside stimulations. At such times it is sometimes possible to pick a specimen up out of the water without causing it to close its shell. Soon after removal from the water, however, the animal recovers and responds as usual. Replaced in the water it may or may not immediately begin to spawn again.

The relation of the genital ducts and kidneys of lamellibranchs has long been considered as important for its possible bearing on the relation of the kidneys to nephridia and the pericardium to a cœlom. In the adult of this form the sexual ducts open into the kidneys near their pericardial ends. Nothing is known about their developmental relation. The openings are much farther from the external openings of the kidneys than I have found to be the case in Yoldia lamatula (5) or Nucula delphinodonta (7) but not so far as in the case of Solenoma where, as Stempell has found (30) for one species (Solemya togata) and I have verified for another one (Solenomya velum) the ducts open very near the pericardial ends of the kidneys. In view of what we know about these and other species studied and reported by Pelseneer, (22) Stempell (29) and others, where it

would seem that we have all gradations from separate openings, near the outer end of the kidneys, openings near the pericardial end of the kidneys, and double openings, so the genital ducts may be connected with the kidneys by branchs and be continued to the outside as well, most of which arrangements are present among members of the Protobranchia, it is still very doubtful whether any significance can be attached to the relationship of the genital ducts and kidneys in different forms.

CIRCULATORY SYSTEM.

The animal is large enough to allow one to successfully inject the chief vessels with starch or gelatin injecting masses, and then by dissection and microscopic preparations to trace the distribution of the vessels of the different organs and to determine quite definitely the course taken by the blood in its circulation.

The heart is a typical, symmetrical lamellibranch heart with two auricles and one ventricle (fig. 11, 13 and 20) the latter perforated by the intestine which enters it near one end and leaves it near the other end. Dorsally the ventricle is prolonged somewhat, posterior to the intestine, where the morphologically anterior aorta is given off, and ventrally to a less extent it is prolonged anterior to the intestine, where the much smaller morphologically posterior aorta is given off. The walls of the ventricle are of about even thickness throughout their extent, and are quite smooth outside and inside. The auricles join the ventricle on each side near its middle, are somewhat triangular in shape, with the most acute angle receiving blood from the gills and mantle, at a point dorsal to the adductor muscle, and directly ventral to, but some distance from, the cartilage. The opening of each auricle into the ventricle is near the middle of the side of the auricle that lies next to the ventricle and farthest away from the opening where the auricle receives its blood. The muscles around the openings of the auricles into the ventricle, and to a less extent around the openings through which the auricles receive blood, are well developed and must act as spinctors that tend to keep the blood from being regurgitated. The walls of the auricles, unlike those of the ventricles, are roughened by pits that open into the cavities of the auricles. These seem to be formed by the arrangement of bands of muscle

fibers along the borders of the pits. The arrangement gives the outside of the auricle a pebbly appearance that is very striking. Both auricles and venticle are composed of interlacing muscle fibers, and are capable of great extension. In preserved specimens, the heart is usually contracted and is not very conspicuous. In such contracted hearts the cavities of both auricles and ventricle are practically obliterated.

The heart lies in a somewhat triangular, spacious, pericardial cavity that is dorsal to the posterior half of the adductor muscle, and ventral to the posterior portion of the liver. Posteriorly, it is covered only by a somewhat thick, muscular membrane which separates it from the mantle chamber.

As already mentioned, two blood vessels leave the ventricle (figs. 11 and 13), one from each end. Although they are not so placed in reference to the ways the terms have been used in describing this form, the two ends correspond to the anterior and posterior ends of the ventricle in most forms of lamellibranchs. The posterior aorta is much the smaller of the two, leaves the heart ventral to the intestine (actually anterior to it) and divides immediately after leaving the heart, into two vessels, one of which, the smaller, follows along the intestine supplying it and surrounding portions with blood. The other vessel turns almost at right angles upon leaving the aorta and enters the adductor muscle, where it divides into a system of vessels that supply the muscle with blood.

The anterior aorta is much larger than the posterior aorta, and supplies all of the remainder of the body. It leaves the ventricle dorsal to (actually posterior to) the intestine and very soon gives rise to a vessel which passes into and supplies the wall that separates the pericardial cavity from the mantle chamber. From the pericardium the anterior aorta follows along the postero-dorsal border of the liver to the base of the ear. Here it gives rise to a branch (fig. 13, ppa.) which passes posteriorly to the extreme upper margin of the mantle that lines the ear, giving off along its course a number of branches which supply this portion of the mantle. Here it divides into two vessels, a right and a left, each of which bends abruptly ventrally (fig. 9, ppa.) and follows along the margin of the respective mantle lobe about opposite the line of attachment of the infolded ridge

of the mantle, alongside but external to the pallial nerve. Very fine branches are given off from these vessels all along their courses, which further divide to form systems of capillary spaces that are finest and most numerous near the margins. Some of these capillary spaces are large enough to be injected with starch mass, and I have a preparation of the mantle lobe from which only the infolded ridge has been removed that was dehydrated, cleared, and mounted in balsam, in which the whole system of vessels can be traced. A gelatin mass not only fills the spaces mentioned, but passes out between the cells so that in sections it may be seen to be diffused throughout the tissue. This seems to hold good for all other parts of the body with the exception of the gills, in which organs the mass is more completely, but not entirely, confined to the blood spaces. The indication therefore is, that the blood spaces are not confined vessels, and that the blood functions as both blood and lymph. The posterior pallial vessel may be traced far anteriorily, gradually diminishing in size along its course. Here it finally joins the anterior pallial vessel. The anterior pallial artery (fig. 13, apa.) leaves the anterior aorta very near the cartilage and runs directly to the anterior border of the hinge region of the mantle, giving off vessels to this portion of the mantle on the way. Here it branches into right and left vessels, each of which bend abruptly ventrally (fig. 9, apa.) and pursues a course along the anterior border of the mantle similar to that taken by the posterior pallial artery at the other extremity of the animal.

Along the anterior border of the mantle, near the dorsal line, the vessel is rather small and slightly broken in its course. It may be possible that this represents the border line between the posterior and the anterior pallial arteries. There are other reasons for believing that a large share of the animal is morphologically equivalent to the posterior portions of other forms, and that the anterior portion is greatly reduced. This has received attention in another place.

Several vessels leave the anterior aorta to supply the liver and stomach. Most prominent among these is a vessel which leaves the aorta between the points of origin of the anterior and posterior pallial arteries. This bends out toward the left side of the liver, where, in injected specimens, it is very conspicuous,

passes ventrally and sends branches to the major part of the liver and to the stomach.

A short distance in front of the cartilage the anterior aorta bends ventrally, passes through the liver and gives off a few small branches to it, sends a vessel to the palps in passing, and passes on to supply the foot and the visceral mass. The vessel that supplies the foot (fig. 13, fa.) leaves the aorta a short distance ventral to the mouth, passes along the body wall until the foot is reached and extends into the foot along its dorsal border. Just before entering the foot this, the pedal artery, gives rise to a small vessel that passes posteriorly along the single retractor muscle of the foot supplying it with blood. From the point of origin of the pedal artery the aorta extends into the visceral mass following along the enlarged portion of the intestine that leads away from the stomach, and supplying this and other portions of the intestine and the reproductive organs with small and with large branches. The enlarged portion of the intestine that comes from the stomach is especially well supplied (compare figs. 12 and 13), there being numerous small branches that are given out directly from the aorta, and large branches that follow along on the different sides of this portion of the intestine and likewise supply it with branches. A short distance ventral to the foot a large branch leaves the aorta and passes postero-ventrally to divide again and form small branches that supply the remaining loops of the intestine and the postero-ventral portions of the reproductive organs.

This completes what might be called the systemic arterial system. Beginning with the heart the system ends in the capillary spaces of the various organs. This system is most easily injected through the vessel in the suspensory membrane of the gills that is farthest from the adductor muscle, (fig. 11, bv.) with a hypodermic syringe, injecting toward the heart. If a starch mass that will not pass through the capillary spaces is used, all of the vessels thus far described will be injected, as will also the veins that return blood from the gills, as this vessel is the one that returns blood from the gills to the heart. If a gelatin mass is used all of the systems may be injected, but as the injecting mass may pass out of the spaces, between the cells of the various organs, such injection does not aid in tracing the course of blood flow.

The systemic veins (fig. 14) that collect the blood that is supplied by the systemic arteries from the various organs of the body, may be injected from several different vessels. They may be injected by pushing the needle beneath the mmbrane that covers the posterior surface of the adductor muscle. A large blood space occupies this position, into which the needle is inserted and the mass injected fills the systemic veins. Another point from which these veins may be injected is from one of the superficial vessels of the visceral mass. These vessels are very conspicuous, and may be very easily picked up with the needle. Still another vessel is the vein that returns blood from the liver, which may be seen on the left side of the animal anterior to, but near the large artery that supplies the liver. Injecting any one of these vessels will to a greater or less extent inject the others, but there does not seem to be an entirely free communication between them. They all carry blood to the kidneys, and seem to empty into a common sinus on either side, that lies alongside the kidney in the walls of the visceral mass. The sinuses of the two sides are conneected beneath the adductor muscle, but it frequently happens that a complete injection of the system is not obtained from an injection from any one of the veins mentioned. Just where the obstruction lies in such cases has not been determined. It has been noticed that obstructions are more likely to be encountered in injecting from the veins of the visceral mass than in injecting any of the others.

Inasmuch as blood spaces are cut in removing the muscle from the shell it has been found desirable in injecting this system of vessels to wedge the valves open and to inject from the posterior surface of the adductor muscle. In injecting after the animal is removed a considerable quantity of the injecting mass is sure to escape at the ends of the muscle.

The position of the veins may be seen in figure 14. A large vein comes from the liver, another from the foot, and the veins in the muscle unite to form a more or less definite sinus along the dorsal border of the muscle, and two smaller ones on the anterior and ventral side of the muscle. These sinuses unite near the anterior end of the kidneys. A series of vessels from the visceral mass unite along the borders of the kidneys and finally connect with these sinuses. Most of the blood from all of

these organs is distributed to the kidneys through systems of capillary spaces. The branching of these vessels is not conspicuous on the surface of the kidneys, but is better seen by cutting the kidneys open. That not all of the blood necessarily traverses the capillary spaces of the kidneys is indicated by the fact that injections of the systemic veins frequently fill the vein that carries blood away from the kidneys as well as those leading to it. This is much more frequently the case when injecting from the posterior surface of the adductor muscle than when injecting from other places, and seems to be dependent upon a direct connection between the vessel in question and the sinuses on the anterior and ventral surface of the adductor muscle near the dorsal ends of the kidneys.

Of the blood that leaves the heart, only that which goes to the mantle remains to be accounted for. This is collected and returned directly to the heart (fig. 9, pv.).

All of the blood that leaves the kidneys is conducted to the gills. The blood from each kidney is collected into a sinus that runs along the border of the kidney that is applied to the adductor muscle. This sinus, which also seems to receive blood from the sinuses on the anterior and ventral surface of the adductor muscle, bends abruptly ventrally over the anterior end of the kidney and is continued on the lower border of the suspensory membrane of the gill (fig. 11, ba.) to the posterior end of the gill, supplying the gill with branches throughout its length.

The blood vessels of the gills have been described in connection with the structure of the gills, but for the sake of completeness the course of the blood through the gills will be traced in this connection.

Blood vessels leave the vessel that carries blood from the kidney, opposite each of the inter-lamellar junctions of each of the gills supported by the suspensory membrane. Each of these branches is continued along the free border of the membrane that forms the inter-lamellar junction (figs. 17 and 18, ba'.) until it reaches the free edge of the lamella, the edge that is not attached to the suspensory membrane. That is, if the branch supplies an outer gill, it leaves the suspensory membrane along the free border of an inter-lamellar junction and crosses over to the free border of the outer lamella of this gill. Here the

vessel is continued down the enlarged, modified filament that is concerned in the formation of the inter-lamellar junction (fig. 17, ba".) giving out side branches through each of the inter-filamenter junctions (as long as these are composed of tissue that can carry blood vessels) and so supplies the various filaments of the lamella. The blood thus distributed finds its way around the margin of the gill through small blood spaces and is continued up the other lamella of the gill, the blood of the small filaments being gradually collected through the vessels of the inter-filamenter junctions into the vessels of the large filaments, (fig. 17, bv'.) and by these poured into a vessel that lies just beneath the vessel that supplies the gill and runs parallel with it (figs. 11 and 18, bv.). This vessel receives all of the blood from both of the gills of the side, and carries it directly to the corresponding auricle of the heart. Just before the vessel empties into the heart it receives a rather large vessel from the corresponding lobe of the mantle which returns the blood that was sent to the mantle, back of the heart.

To sum up the course of the circulation of the blood briefly, it will be seen that of the blood that leaves the heart only that which is sent to the mantle is returned to the heart after traversing a single get of capillary spaces; that a small portion of the blood sent to the adductor muscle (that which is collected by the sinuses on the antro-ventral portion of the muscle) may be returned after traversing two sets of capillaries—those of the adductor muscle and those of the gills; and that the greater portion is returned only after traversing three sets of capillaries—those of the general system, those of the kidneys, and those of the gills.

The reasons for this arrangement of the circulatory system are at least in part not hard to explain. The blood which passes to the mantle loses some of its nourishing materials, but as the mantle lobes are thin and are bathed over such a large portion of their surfaces by a current of water, in which there is an abundance of dissolved oxygen, respiration, no doubt, takes place direct, and the blood has no need to pass through the gills to get a supply. Again the work of the mantle is not of such an active nature as to load the blood with nitrogenous wastes. It seems likely that the amount of nitro-

genous waste in the blood that has traversed the mantle is so small that it would diminish the proportion of nitrogenous waste in the blood, if this blood were added to the blood that passes through the kidneys.

The blood that goes to the general system must in its progress lose a considerable portion of its oxygen, and (in all portions except around the alimentary canal, where there is, of course, a decided gain) food materials, and gain from the waste of the tissues a considerable amount of nitrogenous and carbonaceous wastes. It is then essential that such blood should go to the excretory and respiratory organs to get rid of these waste products and to gain oxygen. Inasmuch as the heart provides for but a single circulation it is, of course, necessary that the capillaries of these organs be traversed before the blood is returned to the heart. Why it is arranged so part of the blood may dodge the kidneys and be carried directly to the gills is not nearly so evident. Possibly the periodically great activity of the adductor muscle causes the blood to move through it so rapidly that the small kidneys cannot take care of it and properly perform their function, and the other channel is provided to carry the surplus away to the comparatively extensive gills where the increased flow can be taken care of with greater ease. It is, of course, essential that the amount of orygen in the blood at such times shall not be reduced. It is at any rate evident that there is a possibility that part of the blood that is returned from the muscle, liver, etc., may not pass through the kidneys, for when starch injecting mass is injected through a vessel that carries blood from one of the kidneys to the gills not only are the kidney and the gill injected, but part of the mass usually finds its way into the adductor muscle, liver, and other organs of the body.

The rate of the heart beat is slow, and as in other lamellibranchs is, no doubt, dependent upon the temperature of the animal as well as on other factors. The auricles and ventricle become very greatly distended during diastole, and contract so that their cavities are almost entirely obliterated in systole.

The three pairs of ganglia that are usually found in lamellibranchs are present in this form, but they differ greatly in size and they are not all placed in the usual positions.

The cerebral ganglia (fig. 15, cg.) are placed some distance ventral to the mouth, just beneath the outer covering of the body. They, like the other ganglia, are yellowish in color, and may frequently be faintly seen through the covering of the body. Each cerebral ganglion is somewhat elliptical in outline with the long axis directed dorso-ventrally and has a rather distinct swelling on the ventral (actually anterior) and outer side (the side away from the median plane of the body) (fig. 24, cg). The anterior end of each cerebral ganglion presents a forked appearance, due to the origin of two large nerve cords. The inner and ventral one of these two cords (figs. 23 and 24, cc.) is the commissure that joins the two cerebral ganglia. As the ganglia lie some distance ventral to the œsophagus, this commissure forms a long loop that passes dorsally around the œsophagus just posterior to the mouth. The outer and posterior of the two large cords that leave the anterior end of each ganglion is the anteror pallial nerve (figs. 15, 23 and 24, apn). This runs parallel with the commissure as far as the œsophagus and is then continued along the side of the liver and in the mantle, to the margin of the mantle in the region of the anterior ear of the shell, where it joins by several branches the circum-pallial nerve (cpn.) that follows along the margin of the mantle near the bases of the tentacles and eyes. The circum-pallial nerve will receive attention later.

Between the points of origin of the cerebral commissure and the pallial nerve, a small nerve (figs. 23 and 24, pn.) leaves the ganglion to be continued dorsally, and to supply the labial palp.

From the inner, ventral surface of each cerebral ganglion, a little in front of the middle, the cerebro-pedal connective leaves to join the pedal ganglion of the same side. The cerebro-pedal connective is smaller near the cerebral than the pedal ganglion (fig. 24, cpc.) and bears a ganglionic swelling on its outer side very near the pedal ganglion.

In the acute angle formed by the surface of the cerebral ganglion and the cerebro-pedal connective, a small nerve (otn.),

the otocystic nerve, leaves the ganglion to be continued around the dorsal surface of the cerebro-pedal connective to the otocyst of the same side. This nerve will receive attention later.

Posteriorly the cerebral-ganglia taper rather gradually into the cerebral-visceral connectives which run along the sides of the visceral mass very near the adductor muscle until the visceral ganglia are reached.

The pedal ganglia lie very near each other (fig. 24, pg.), so the commissure that connects them is short and broad and presents ordinary ganglionic structure. They are separated from the cerebral ganglia only by a short interval, and lie anterior and slightly ventral to them, some distance dorsal to the base of the foot. They lie so near the surface that their color may frequently be distinguished through the body wall beneath the mouth. Two large nerves (fn.) leave each pedal ganglion to be continued into the foot where they supply the muscles of the foot and probably the byssal gland. The swellings on the cerebro-pedal connectives near the pedal ganglia have already been described. The otocystic nerves which usually leave the cerebro-pedal connectives near the pedal ganglia, in this form originate directly from the cerebral ganglia near the point where the connectives leave the ganglia.

The visceral ganglia (figs. 15, 23, and 25, vg.) are by far the largest and most complicated of the ganglia, and from them nerves are sent to most parts of the body. They are situated on the antro-ventral surface of the adductor muscle, nearly opposite the external opening of the kidneys. They are imbedded in a mass of connective tissue and are fused to each other so the commissure that connects them is nearly as broad as the ganglia themselves and shows ganglionic structure. The chief indication of the presence of a pair of ganglia is the arrangement of the nerves that leave them, and of the celebro-visceral connectives that join them. The ganglia are divided into very definite regions, each of which is connected with definite bundles of nerve fibers and, no doubt, has a particular function to perform. I have not had time to make a detailed study of the structure and nerve tracts of the ganglia, but I am satisfied that there is much more complexity than is ordinarily attributed to the ganglia of lamellibranchs. The dorsal surfaces of the ganglia are

quite smooth, but when seen from the ventral surface (fig. 25) the regions that are indicated in the figure are always visible. On each cerebro-visceral connective, just before it joins the ganglion proper, there is a ganglionic swelling (x.) that supplies one of two roots of a nerve (figs. 15, 23, and 25, bn.) that leaves in an antro-dorsal direction along the border of the excretory organ, to bend ventrally and posteriorly in the suspensory membrane of the gills, and supply the gills of the corresponding side. Between the points where the cerebro-visceral connectives join the visceral ganglia, on the ventral side, there are four rather distinct swellings, with three less distinct swellings posterior to them. Extending laterally from the outer side of each ganglion is a somewhat flattened ridge (fig. 25. y.) from which all of the pallial nerves from this ganglion originate. These nerves (figs. 15 and 23, ppn.) pass laterally, posteriorly and anteriorly along the surface of the adductor muscle, to meet the mantle lobe and to be continued to the margins, where they unite with the circum-pallial nerve. It will be noticed that they unite with the circum-pallial nerve at intervals throughout the greater length of these nerves. As the pallial nerves that leave the visceral ganglia are in most forms distributed to the posterior portion of the mantle only, the distribution in this form may be looked upon as evidence that all of this portion of the mantle belongs morphologically to the posterior portion of the animal.

Other nerves leave the dorsal surface of the visceral ganglia near their posterior ends, and enter the adductor muscle directly. The nerves that supply the posterior division of the muscle are continued along the ventral surface of the anterior portion of the adductor muscle until this posterior portion is reached. Small nerves also leave the ventral side of the ganglia and penetrate the visceral mass.

All of the ganglia are well supplied with nerve cells, there being very many large polar cells present, but the number of the cells is far greater and their arrangement more complicated inthe visceral than in any of the other ganglia.

Nerve cells are also to be found in the circum-pallial nerves and in the branchial nerves. So abundant are the nerve cells in the circum-pallial nerves that they assume the structure of

ganglia. The nerves by which they are connected with the visceral and cerebral ganglia contain no ganglionic cells. From the structural standpoint we would accordingly be justified in considering the circum-pallial nerves as separate ganglia, and the nerves connecting them with the visceral and cerebral ganglia as connectives.

The circum-pallial nerves of the two lobes of the mantle are connected with each other anteriorly and posteriorly near the hinge line (fig. 23, cpn). They are not of constant diameter but suddenly increase or diminish in size so that they have a rather irregular appearance. They lie just inside, that is, toward the median plane of the body, of the large pallial arteries that supply the mantle margin (fig. 26, cpn.) about opposite the line of attachment of the infolded ridge. From them nerves are sent to the eyes and tentacles, to the infolded ridges and to the pallial muscles. Very likely the pallial muscles are partially supplied from the pallial nerves that come from the visceral ganglia, but of this I am not sure.

It seems probable that the ganglionic structure of these nerves has been developed to meet the needs of the very complex margins of the mantle. The development of such structure in the immediate region of the sense organs, is an indication of the ease with which such centers may be established when need arises. The branchial nerves are supplied with ganglionic cells throughout their length. These are present not only along the borders of the gills, but from the points where the nerves originate to their extremities. The almost constant activity of the gills no doubt renders such an arrangement desirable. No other nerves or connectives in the body seem to be supplied with ganglion cells.

The whole nervous system is modfied to meet the special needs of the animal. The cerebral and pedal ganglia are small, corresponding with the slight development of the anterior parts of the body and of the foot. The visceral ganglia are highly developed, corresponding to the excessive development of the parts that are supplied by these ganglia. Accessory centers have also been developed in the margins of the mantle and in the gills.

It seems that students of Mollusca quite commonly hold that the lamellibranch ganglia have been derived from a gastropod-like type, a type that possess at least one pair of ganglia, the pleural, that are not commonly found in lamellibranchs. This view seems to be based largely upon the acceptance of a hypothetical type for a primitive mollusk that seems to me to be a much better ancestor for the gastropods than for the other classes of the Mollusca. The discussion of this hypothetical form may be left for another place, but the discussion of the nervous system properly belongs here. About all of the actual evidence that we have of the presence of pleural ganglia in lamellibranchs is that in Nucula (22) and some other forms the anterior ganglionic mass is so shaped that it is possible to consider it as two ganglionic masses, and further that the connective that runs from this mass to the pedal ganglion is connected with this mass by two roots. The interpretation (22) that has been put on this is that the two apparent divisions of the ganglion represent respectively the cerebral and pleural ganglion, and that the roots of the connective represent the cerebro-pedal and pleuro-pedal connectives that have become fused before reaching the pedal ganglion. My own view, discussed in another paper (7) is that the apparent division into two ganglionic masses is superficial, and due to the swellings accompanying the origins of nerves, and that one of the cerebral ends of the connective may be the central end of the otocystic nerve which is fused for the greater part of its length with the connective, but, unlike most forms, is free near the ganglion. This view seemed to me most reasonable as Stempell (30) has found that in Soleyma togata, a supposed near relative of Nucula, the otocystic nerve arises directly from the cerebral ganglion and is separate from the connective throughout its length. So far as I know, the instance given by Stempell is the only one that has heretofore been reported where the otocystic nerves originate from the cerebral ganglia, and are free from the cerebro-pedal connectives throughout their length. Pecten tenuicostatus has the same arrangement. In this form the position of the ganglia, connectives and otocysts is such that it is a very simple matter for the otocystic nerves to make direct connection with the cerebral ganglia, but they do not join the ganglia at their nearest

point. Instead they are continued around the connectives to join the ganglia in contact with, and posterior to them.

To me it seems probable that the separation into the two groups that have developed into the classes Lamellibranchiata and Gastropoda took place at an early date in the history of the Mollusca, probably before a complicated head apparatus was developed, and while the nervous system was of a very simple nature. If this was the case, we have no reason to search for pleural ganglia in lamellibranchs, for it is very probable that they never had them. In fact were ganglia ever present in this region in lamellibranchs, it would be more reasonable to view them as new formations for special purposes than as direct descendants from, and accordingly homologous with, the pleural ganglia of gastropods. The gastropod and lamellibranch are so different in structure and habits that we may reasonably expect important differences in their nervous systems. Gastropods and Cephalopods possess accessory ganglia that have evidently been developed to perform special functions. That such centers may be comparatively easily developed is indicated by the fact that the circum-pallial nerves of the scallop are essentially such centers. Is it not then more likely that pleural ganglia have been developed in the groups that need them than that lamellibranchs, which, so far as we know have never been more complicated than they are to-day, should have formerly possessed these ganglia and have since quite uniformly lost them?

Eyes.— SENSE ORGANS.

The number and position of the eyes has been discussed in connection with the structure of the mantle, on the lobes of which they are borne. They have been so frequently and well described by other investigators that it does not seem necessary to give a detailed description here. Each eye (fig. 26) is club-shaped, pigmented near its outer end, and its position and general appearance indicate that it is probably a modified tentacle. The extreme end is occupied by the cornea, (co.) which consists of a single layer of transparent epithelial cells that are continuous with the layer of somewhat thicker cells that forms the remainder of the covering of the tentacle. Near the free extremity these cells are completely filled with a dark-brown or

nearly black pigment, which gives the color already referred to, so that in sections of large eyes, where the pigmentation is deepest, the nuclei of the cells are not easily found. The pigmentation becomes less dense toward the base of the tentacle and gradually disappears. Muscle fibers that extend back into the eye stalk are attached to the edges of the cornea so in preserved specimens it is not uncommon to find the cornea pulled back so the pigmented portion extends around it as a ridge. These muscles may be of use in changing the focus of the eye. So far as I know, there is no other provision for focussing.

The lens (le.) is cellular in structure, and except for a thin layer of muscle and connective tissue fibers that cover its outer surface and are continuous with the muscle fibers at the edge of the cornea, it is in contact with the inner surface of the cornea. There is no space between them so the cornea, muscles and lens form a single optical lens. The inner surface of the lens is applied to the retina, (r.) but as part of the nerve (on.) that supplies the retina enters the eye from one side, the nerve is continued between the retina and the lens. The edges of the lens are bounded by a blood space.

In sections the lens varies greatly in shape. It may be nearly circular, indicating that the lens is nearly globular, or either its anterior or its posterior face may be greatly flattened. The shape shown in figure 26 is not uncommon, but sections in which the posterior face is drawn out and is very convex are not at all rare. It is a question whether these shapes indicate a possible focal range, or whether they are to a considerable extent distortions due to preservation.

The flattening of the outer face of the lens may be accomplished by the muscles that are attached to the margin of the cornea, and that are continued over the surface of the lens between it and the cornea. It is possible that injecting the blood space with blood and contracting muscles in the eye stalk which surround this blood space, may lengthen the lens—that is, make it more convex. The mechanism is not very complete, but it is hardly to be expected that focal changes take place with great rapidity.

The retina is rather thick, and is slightly concave toward the lens, with which it is always in contact. The exceedingly con-

vex lens is no doubt sufficient to bring the light to a focus on the retina, although the retina is in contact with the surface of the lens. Judging from section it seems likely that the refractive indices of the cornea, lens, and retina are practically the same. If this is the case, the only refraction that takes place is when the light enters the cornea. In this case the relative convexity of the outer surface of the cornea determines the focal distance, and the shape of the inner portion of the eye is immaterial as long as the lens and retina are kept in contact. With such an arrangement the more convex the cornea the shorter the lens must be in order to place the retina at the focal distance, and vice versa.

The nerve that enters the eye on the side next to the shell, just in front of the surface of the retina that is applied to the lens, supplies the retina. The layer that resembles rods is placed on the side turned away from the lens, and it is to these that the nerve fibers are apparently distributed. A pigment layer, often of considerable thickness, lies next to the rods. Another nerve, a branch of the one already described, reaches the eye near its optical axis, and spreads out beneath this pigment layer. I have not traced its distribution.

Looking directly into it, the eye universally appears blue. The color is probably due to the breaking up of the light reflected from it by the small elements of which it is composed as there seems to be no blue pigment.

The development of the eye has not been carefully followed. It is noticeable that the small, presumably young eyes, have proportionately much thicker corneas than the large eyes have.

It is a difficult matter to determine by experiment how well a scallop sees. If an animal is placed in a position that is illuminated from one side, and allowed to remain undisturbed for some time, and then a sudden shadow is made to fall over it, it is almost sure to suddenly close its shell. If this be tried several times at short intervals the animal usually soon fails to respond. It is also to be noticed that Pecten irradians when approached in shallow water will either start to swim or close its valves. It is, of course, not at all certain that the stimulation that leads to this action is received through the eyes. The response is much more noticeable than with most other shallow

water forms, but the scallop is naturally more active, and is well supplied with tactile tentacles as well as with eyes.

Quick motions outside of an aquarium made so the illumination is not materially affected, and so the aquarium is not jarred, frequently seem to cause response, but the results are so frequently negative that apparent responses may be accidental. Experiments to test the power of vision have not been devised.

Tentacles.—

The number and arrangement of the tentacles has been discussed in treating the mantle. Although the size, shape, and position of the tentacles differ considerably, they are all essentially of the same structure. As they are included in the color pattern of the margins of the mantle, some are pigmented and others are not. The tentacles are quite smooth when they are extended, and short, wrinkled, and conical when retracted. Each tentacle is covered by a layer of epithelium and bears near its free extremity several conical projections, "pinselzellen," each of which bears a cluster of sense cilia at its tip. These projections are always more numerous near the extremities of the tentacles than elsewhere, but they are scattered pretty well over their surfaces and may occur on the mantle also. Each tentacle (fig. 22) is supplied with a large nerve (n.) derived from the circum-pallial nerve, that runs the whole length of the tentacle near its middle line. Nerve cells are present in this nerve throughout its length. A connective tissue framework divides the interior into a number of spaces. Muscle fibers (mf.) that run lengthwise of the tentacle lie alongside the framework and surround the blood spaces (bs.). The nerve lies very near the center of the framework and occupies one side of a large blood space. The structure is very much the same as that of the special sense tentacle of Yoldia (5). The chief difference is, that in this tentacle there are a number of blood spaces, while in Yoldia there is only one.

The blood spaces serve to lengthen the tentacle, by having blood forced into them, and the muscle fibers shorten it.

Otocysts.—

The otocysts (figs. 15 and 24, ot.) are placed very near, and almost dorsal to the pedal ganglia, and accordingly not far from

the cerebral ganglia, but a little ventral, anterior and nearer the median plane of the body than these ganglia. The otocysts are imbedded in a mass of connective tissue that surrounds the pedal ganglia, and may with comparative ease be dissected out with the pedal and the cerebral ganglia, and studied in total mounts.

Each otocyst consists of a nearly spherical pouch formed of epithelial cells that is connected with the exterior by a small canal (fig. 24, otc.) that opens almost opposite the cerebral ganglion of the corresponding side. Similar canals are present either as complete canals or as rudiments in different species of the Protobranchia, but so far as I know, have never before been described for any species outside of this group. As otocysts uniformly originate as invaginations from the surface epithelium of the animal possessing them, it is reasonable to suppose that these canals are simply persistent from the embryological condition, but this has not yet been proved. The otocysts are ciliated (whether the cilia are vibratile or not has not been observed) and usually contain a considerable mass of fine granular material that may be scattered, or collected into a very definte ball. It is not at all uncommon to find one otocyst nearly filled with this material, while the other is nearly empty. On the other hand, both may be nearly filled, or both may be nearly empty. The origin of this material is doubtful. In appearance it resembles fine fragments of debris such as is found on the bottoms where the scallops live, and there is sometimes some variation in the color of these particles. All of the particles seem to be sufficiently small to have been introduced through the otocystic canals, but I have not thus far found any of the shells of diatoms although the mud on which the animals live is full of them and many of them are as small as the particles that are found in the otocysts. The irregular, broken appearance of the particles and the fact that frequently there are many more particles in one otocyst than in the other rather points to their being foreign particles than to their being products of secretion.

The otocysts are usually considered to be static organs. So far as I know, there are no experiments that bear on the function of these organs in lamellibranchs, and the supposition that they are organs for determining position in space is based upon

experiments on supposedly similar organs in other forms. The scallop normally lies on the right shell valve, but I am not sure that it makes any particular effort to turn over when it is placed on the other valve. When it swims and settles to the bottom, it settles uniformly on the right valve. Whether this is due to the shape of the shell or to some determining factor outside of the nervous system of the scallop or not, is not known.

EMBRYOLOGY.

From observations made early in the summer, it seemed probable that the giant scallop spawned rather late in the season; accordingly as soon as other duties permitted, August 20, 1901, quarters were procured at Bass Harbor, Mt. Desert Island, Maine, and work begun. Examination of specimens showed that for the most part they had not spawned, and that spermatoza removed from the testis and placed in sea water were active. Many trials were made while at Bass Harbor to artificially fertilize the eggs by cutting them out and mixing them with sea water containing sperm which had likewise been procured by cutting. Very few of the eggs showed any signs of development, and most of them that started did not develop normally. Eggs thus removed from a lamellibranch are irregular in shape, due no doubt to their crowded condition in the ovaries. For some reason that is not understood, the eggs of many species of lamellibranchs seldom round up, are incapable of fertilization, and soon go to pieces when they are cut out of the ovary. Such is the case with this form. Eggs removed even during the height of the breeding season did not develop well.

It was found that scallops that were full of eggs and sperm when placed in a floating car on August 23rd, had, when examined the next day, thrown most of their sexual products. Specimens had also been placed in large vessels of water at the same time, but these had not spawned and did not spawn although kept another day. The animals die rapidly in such vessels of water, seldom living more than three days, and frequently not more than one. A careful watch indicated that specimens put in the car did not spawn during the middle part of the day, so night observations were made. Fresh specimens were placed in the

car and in a dory that had been carefully cleaned and partly filled with water, and left floating so that the temperature would remain something like that of the sea water outside. At intervals of a half hour up to midnight, the scallops in the car were examined by lantern light and a little of the water in the dory was examined microscopically, to see if eggs or sperm could be discovered. As they were apparently not spawning, they were left until just before sunrise, when observations were again begun. About 8 A. M. sperm were discovered in the water of the dory. Soon after several specimens began to throw sperm in such quantities that the water in their vicinity was turbid. Upon going to the car it was found that the water in the car and for some distance outside was so full of eggs and sperm that they could be dipped up in such numbers that the bottoms of white agate ware dish pans filled with the water became pink with the eggs that settled. The water was decanted and the eggs supplied with fresh sea water. Some of the eggs were transferred to glass dishes that were covered by loose glass plates that prevented undue evaporation, and excluded dirt that was rather in evidence in the shed on the steamboat wharf that served as a laboratory. Water was changed in all of the vessels at intervals during the time that the embryos remained alive.

The scallops that were put in the dory were removed as soon as eggs were abundant, and after allowing a few minutes for the eggs to settle, most of the water was dipped out and replaced by pure sea water. The results were not satisfactory, however, and as at 6 P. M. the embryos in the dory did not seem to be doing well, not much further attention was given them. All of them apparently died before those in the dishes were in bad condition. This is not strange, as a large quantity of sperm had to be left in the dory, and it was not possible to give the embryos as good care in the bottom of a comparatively foul dory as in the cleaner dishes.

The development is what may be considered normal for lamellibranchs. There is no part of the early larval history that is different from what might be expected for such a form, as it differs very little from Teredo (9 and 27), Dressinia (19), Ostrea (4), Mya (18), Cardium, and a host of others that have

been described, or are familiar to every worker on lamellibranch embryology.

It will accordingly be necessary to describe the formation of the embryos only very briefly. As the age of the eggs could not be accurately determined it is not possible to give the exact time that elapsed before the polar bodies made their appearance, but probably the first polar body was given off in from half to three-quarters of an hour after the egg was laid. The first external sign of activity after fertilization is the formation of a prominent yolk-lobe, which nearly disappears after the first polar body is formed, to become prominent again when the second polar body is formed (fig. 27) and to disappear again after this is separated from the egg. It again becomes prominent when the egg cleaves into two cells, (fig. 29) and is slightly visible during the second cleavage. The polar bodies are given off from the side of the egg that is opposite the yolk-lobe, and although the egg is not inclosed in a membrane as is the case in many forms, the polar bodies adhere until the cells are provided with cilia and the embryo begins to swim. The adherence is apparently due to protoplasmic strands such as have been described by Andrews (1 and 2).

The first plane of cleavage passes through the point where the polar bodies were formed, and just to one side of the yolk-lobe (fig. 29). This divides the egg into two unequal portions, the larger of which contains the whole of the yolk-lobe. The next cleavage plane also passes through the point where the polar bodies were formed and nearly at right angles to the first cleavage plane (fig. 30). This also passes a little to one side of the yolk-lobe so at least a large portion of the yolk remains in one cell which is larger than the others.

The division into eight cells is accomplished by cleavage planes at right angles to the planes already described (fig. 31). In this way each of the four cells are divided unequally, those nearest the polar bodies being smaller than those on the opposite side. Continued division of the cells results in the formation of a mass of cells (fig. 32) some of which are confined to the surface, while others are large and extend into the interior, thus forming an almost typical epibolic gastrula. This stage of development is reached in from 12 to 14 hours, at which time

many of the surface cells have acquired cilia and the embryos begin to roll around on the bottom of the dish.

An hour or two later the apical cilia make their appearance. They at first are not much longer than the others, and do not seem to be very numerous. Because of their motion and tendency to bunch together they are hard to count, but only four or five seem to be present at this early stage. They grow quite rapidly until they are nearly as long as the diameter of the embryo and increase in number until a considerable bunch is formed.

About this time the embryo begins to elongate slightly in the axis roughly corresponding to the direction of the apical tuft of cilia and the embryo begins to swim freely in the water. The motion is not very rapid, and is at first rolling, but as the apical cilia elongate the embryo begins to swim in definite lines, always with the apical cilia pointing forward. In swimming the embryo varies its direction almost constantly, and continually rotates on its longitudinal axis. The direction of the rotation may be changed from time to time.

Sections at this stage (fig. 33) show two pouches formed by the invagination of the surface layer of cells. On what is to become the dorsal portion of the animal, nearly opposite the apical cilia, is the larger of these two pouches (sg.). It is composed of large cells that are continuous with the surface cells. This is the shell gland. It soon spreads out and grows down on the sides to form the lobes of the mantle and to secrete the shell. The other invagination (ar.) is somewhat smaller than the one just described, is composed of smaller cells, and is situated on the ventral side. Like the other, this is continuous with the surface layer of cells. It has been formed apparently partially by the pushing in of surface cells, and partially by the division and separation of cells on the inside of the embryo. This is the first appearance of the alimentary canal, and probably represents a combined archenteron and stomodæum. The inner ends of the shell gland and archenteron lie very close to each other and may for a time be in contact. With the spreading out of the shell gland, which is accomplished in about 18 or 20 hours after the egg is fertilized, the embryo elongates decidedly (fig. 34) and

becomes somewhat pointed behind; that is, the end directed away from the apical cilia becomes the pointed end. The embryo enlarges, due to the formation of a space beneath the shell gland, which has now become the mantle, and the surface cilia become restricted to the anterior end. The archenteron begins to grow rapidly, enlarges to form the stomach, (s.) and grows posteriorly to form the intestine (i.). The anterior adductor muscle (aam.) makes its appearance dorsal to the apical plate (ap.) and posterior to the dorsal margin of the portion that bears surface cilia, which later develops into the velum. The space between the developing alimentary canal and the body wall is quite extensive, practically surrounding the alimentary canal except where it joins the body wall at each end and where the anterior end of the stomach is in contact with the apical plate. The adductor muscle is in contact with the body wall on its anterior surface, but is otherwise surrounded by this space. A few greatly elongated spindle-shaped fibers resembling muscle fibers usually extend across the space. Almost universally one or two such fibers extend from the dorsal surface of the stomach dorsally and posteriorly to the body wall. Similar fibers have been noticed in the embryos of other lamellibranchs and are quite conspicuous in Nucula, (7) but their function is not known. The space is no doubt a schizocœle that is formed as the result of the arching up of the shell gland to form the mantle. This takes place much more rapidly than the internal organs grow, and the space is accordingly formed. Its ultimate fate has not been traced as the oldest of the embryos reared still have a remnant of it dorsal to the alimentary canal.

The stage that has been described is practically a trochophore. The cilia are in front of the mouth, but cover the whole area around the apical tuft instead of being arranged to form a band. Later, as the velum is formed, they are better developed along the margins of its lobes and thus form a band.

A stage similar to this is probably present in all forms of lamellibranchs that do not give protection to their embryos as is done by the Unionidæ, Sphærium, etc. Even here (32) something that corresponds to the stage may be recognized. At first sight the embryos of Yoldia (5) and Nucula (7) seem to differ considerably from the trochophore that has been described,

but this is apparent rather than real. If the ciliated cells that cover these larvæ and form the tests, were pushed forward and the stomodæum shortened so the mouth would retain its position at the margin of the ciliated area, the two larvæ would be essentially alike. At a slightly earlier stage in Pecten a large part of the surface is covered with cilia, and this is changed only by the posterior development of the embryo, beginning with the flattening of the shell gland. Such a posterior development is normal in many trochophores as in the case of Dondersia (23), Dentalium (17), Chiton (10 and 16), and most lamellibranchs and gastropods, as well as in annelids, where the posterior development is so marked.

The shell gland spreads out laterally and forms the lobes of the mantle which secrete the shell valves (figs. 35 and 36). The ciliated area grows rapidly and forms the two lobes of the velum (vl.). The cerebral ganglon (cg.) are formed near the apical plate. The alimentary canal grows dorsally and is bent into the shape of a U. The stomach (s.) enlarges, the intestine (i.) acquires an anal opening, the greater part of the schizocœle becomes filled with mesoderm and the embryo assumes the form of a veliger. This change is accomplished inside of three or four hours, so active veligers are formed in about thirty hours after the eggs are laid. The shape of the embryonic shell is quite characteristic for the embryonic shells of lamellibranchs (12) and differs very greatly from the adult form. Risser reports that this is not the case with Pecten irradians (24) but the shells on very young embryos that I have reared are very similar. Until this stage is reached the embryos take little or no food. They now swim about actively through the water, frequently going to the surface. The cilia on the edges of the lobes of the velum are the means of locomotion. The apical cilia remain bunched and are moved rather gently in different directions but apparently function as sensory rather than locomotary cilia. Each individual occasionally retracts its velum between the valves of its shell, closes its shell, and slowly settles to the bottom. This is almost always the case whenever the animal is disturbed, as by jarring the dish in which the veliger is swimming, or when the animal runs into anything or is run into by another animal. In such

cases the veliger may recover after falling a short distance, or it may fall to the bottom and remain quiet for some time. The response to disturbance, which is the usual response of lamellibranch veligers, has been taken into account by Mead and Barnes (18) who have devised a trap whereby quantities of the veligers of the soft-shelled clam, Mya arenaria, can be collected and reared without trouble to such a size that they may be used as seed in stocking clam ground.

The embryos of most lamellibranchs usually remain as veligers and swim about freely for a number of days, or even for some weeks. The embryos of Pecten were kept alive for only five days. Weather and an unsatisfactory place to work interfered with proper care and they were apparently weakened by starvation. This difficulty could probably easily be overcome, as in other cases, by putting them in vessels of sea water in which cultures of the diatoms that supply the greater part of their natural food have been started, but cultures could not be started at the time, and there have since been no opportunities to return to the scallop grounds during the breeding season. The young of Nucula proxima reared from eggs, have been kept alive for eleven months in a small jar of sea water in which a small quantity of mud from the bottom had been placed after straining it through silk bolting cloth to remove forms that might be enemies.

Many fishermen report having seen the young scallops attached to shells by means of threads during the early winter. In a few cases small Anomia were brought to me as young scallops, but most of the fishermen to whom these were shown did not accept them as young scallops. Their descriptions of young scallops were in some cases quite minute, and apparently accurate, and in all such cases the scallops were said to be attached by threads. Pecten irradians is known to attach itself by a byssus in the young (24) and even in the adult stage, and it is very probable that the young of the giant scallop attach themselves in the same way. If so, when the veligers settle permanently to the bottom, they must find something on which to attach themselves in order to keep from being destroyed. If this is true, the absence of suitable material for this purpose may be the reason that many of the old grounds, especially the shallow

water grounds that have been much dredged, no longer support scallops. The present custom is to shuck the scallop before leaving the grounds, but the shells are usually badly attacked by boring sponges, and go to pieces quickly, so it is possible that they may not be of service when the breedng season arrives. I have had no opportunity to examine the run-out grounds, nor to make a careful study of existing beds, so the above are simply surmises that may not agree with facts.

SUMMARY.

Shell.—

The shell is adapted for swimming, in shape, in weight, in the position and strength of the muscle, and in the possession of a large cartilage, and a straight hinge line which will allow rapid movement without great strains or friction. (See pp. 7-11, and Figs. 1-7.)

Mantle.—

The mantle lobes are supplied with numerous sense tentacles and eyes which are probably of use in detecting enemies; with nerves that possess ganglion cells; with infolded ridges that regulate the opening of the mantle chamber when the shell is open and probably serve to direct the current of water thrown from the shell in swimming; and with strong pallial muscles which serve to withdraw the margins of the mantle when the shell is closed. (See pp. 12-16 and Figs. 9, 10, 16, 20 and 26.)

Foot.—

The foot is comparatively small, split at the end, and possesses a large byssal gland. It is probably not of much service in locomotion. The retractor muscle of the left side only is retained. (See pp. 16-19 and Figs. 8, 10, and 12.)

Alimentary Canal.—

The stomach lies near the hinge line surrounded by the liver. The portion of the intestine that leaves the stomach corresponds with it in structure. It seems probable that one loop of the intestine has been overlooked in previous dissections of scallops. (See pp. 19 and 20, and Fig. 12.)

Labial Palps.—

Unlike most forms, the palps are ruffled above and below the mouth. The reason for the arrangement is not known. (See pp. 20 and 21, and figs. 10 and 12.)

Gills.—

Each gill is attached by one lamella to a muscular membrane that serves to elevate the gills when the shell is closed. The other lamella is not attached. This arrangement makes it possible for the water to be thrown from the shell in swimming without injuring the gills. The inter-filamenter junctions are composed of cilia near the margins of the gills, and of tissue near the suspensory membranes. Their blood vascular supply is intricate. (See pp. 21-30, and figs. 11, 12, 17, 18, 19, 20, and 21.)

Muscular System.—

The anterior adductor muscle is lost at an early period of development. The posterior adductor muscle is distinctly separated into an anterior and a posterior portion. The anterior portion, which is much the larger of the two, may be cut without causing the shell valves to gap. If the posterior portion is cut without injuring the anterior portion, the valves immediately open.

Muscles for withdrawing the margins of the mantle and the gills are well developed. Only the left retractor muscle of the foot is present in the adult animal. (See pp. 31 and 32, and figs. 10, 16, 19, 20, and 26.)

Excretory Organs.—

These are essentially rather large sacs with glandular walls. They receive the genital ducts near their pericardial ends. (See pp. 32 and 33, and figs. 13 and 20.)

Genital Organs.

The genital organs are large, pink in the female, and white in the male. The genital ducts join the excretory organs near their pericardial ends. (See pp. 33-35.)

Circulatory System.—

The large size of the animal makes it possible to inject the vascular system successfully. Blood from the mantle is returned immediately to the heart. Most of the blood from other portions is returned to the kidneys, from which it is carried to the gills and then back to the heart. A portion may dodge the kidneys and go to the gills. Blood seems to act both as blood and lymph. (See pp. 35-42, and figs. 9, 11, 13, 14, 17, and 21.)

Nervous System.—

The cerebral and pedal ganglia are small and somewhat removed from their usual positions. The visceral ganglia are very large and compli-

cated in structure. The circum-pallial nerves and the branchial nerves have ganglion cells throughout their length. The otocystic nerves originate directly from the cerebral ganglia. (See pp. 43-48, and figs. 15, 23, 24, and 25.)

Sense Organs.—

The eyes are numerous and optically arranged for the formation of images. The sense tentacles are exceedingly numerous and of ordinary structure. The otocysts have canals that open at the surface of the body and the otocystic nerves join the cerebral ganglia direct. The otoliths are composed of granular material that may have been introduced from the outside. (See pp. 48-53, and figs. 10, 20, 22, 24, and 26.)

Embryology.—

The development is normal and rather rapid. (See pp. 53-60, and figs. 27-36.)

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REFERENCE LETTERS.

a. Auricle.
aa. Anterior aorta.
aam. Anteroir adductor muscle.
ac. Apical cilia.
ap. Apical plate.
apa. Anterior pallial artery.
apn. Anterior pallial nerve.
aps. Anterior pallial scar.
ar. Archenteron.
ba. Branchial artery.
ba′. Branches of the branchial artery.
ba″. Branches of the branchial artery in the modified filaments.
bg. Byssal gland.
bn. Branchial nerve.
bs. Blood space.
bv. Branchial vein.
bv′. Branches of the branchial vein.
c. Cartilage.
cc. Cerebral commissure.
cg. Cerebral gangloin.
cgl. Cuticular gland.
co. Cornea.
cp. Cartilage pit.
cpc. Cerebro-pedal connective.
cpm. Circular pallial muscles.
cpm′. Circular pallial muscles of the infolded ridge.
cpn. Circum-pallial nerve.
cr. Chitinous rods.
cvc. Cerebro-visceral connective.
e. Excretory organ.
f. Foot.
fa. Foot artery.
fc. Feeding cilia.
fe. Free edge of the unattached lamella.
fm. Foot muscle.
fn. Foot nerve.

fs. Filament support, probably to keep the filament from swelling into a cylindrical shape with the pressure of the blood.
fv. Foot vein.
g. Gill.
gf. Gill filament.
i. Intestine.
ifj. Inter-filamentar junction.
ig. Inner gill.
ilj. Inter-lamellar junction.
io. Inhalent ostium.
ir. Infolded ridge of the mantle.
l. Liver.
le. Lens.
lm. Longitudinal muscles.
lp. Labial palps.
lv. Left valve of the shell.
m. Mantle.
mf. Muscle fibers.
n. Nerve.
oc. Ostium cilia.
oe. Œsophagus.
og. Outer gill.
on. Optic nerve.
ot. Otocyst.
otn. Otocystic nerve.
p. Pericardial cavity.
pa. Posterior adductor muscle, anterior portion.
pa'. Posterior adductor muscle, posterior portion.
paa. Posterior adductor artery.
pas. Posterior adductor muscle scar, anterior portion.
pas'. Posterior adductor muscle scar, posterior portion
pav. Posterior adductor muscle vein.
pg. Pedal ganglion.
pl. Pallial line.
pn. Palp nerve.
ppa. Posterior pallial artery.
ppn. Posterior pallial nerve.
pps. Posterior pallial scar.
pv. Pallial vein.
r. Retina.
rpm. Radial pallial muscles.
rv. Right valve of the shell.
s. Stomach.
sg. Shell gland.
sm. Suspensory membranes of the gills.
sms. Suspensory membrane scars.

st. Sense tentacle.
v. Ventricle.
va. Visceral arteries.
vg. Visceral ganglion.
vl. Velum.
vm. Visceral mass.
vv. Visceral veins.
x. Swelling on the visceral ganglion from which the anterior root of the branchial nerve originates.
y. Swelling on the visceral ganglion from which the posterior pallial nerves originate.

PLATE 1.

FIG. 1.—A well preserved left shell valve showing the markings on the outer surface. Two-thirds natural size.

FIG. 2.—Outer surface of a left shell valve that shows distinct radial color markings. Two-thirds natural size.

PLATE 2.

FIG. 3.—Left shell valve badly mutilated by the attacks of boring sponges. The large barnacle near the margin of the valve shows that the rate of growth has not been very rapid for some time. Two-thirds natural size.

FIG. 4.—Outer surface of a right shell valve. The valve is flatter than its mate and has a conspicuous notch at the base of the anterior wing. The radiating ridges are worn so they are not as conspicuous as they are on the other valve. This valve is usually lighter in color than the left. The relatively dark color here is due to different printing. The round openings on the surface are due to recent attacks of the boring sponge. Two-thirds natural size.

PLATE 3.

FIG. 5.—Inside of a left shell valve. The markings on the inside of the left shell valve are never as conspicuous as they are on the inside of the right shell valve. Two-thirds natural size.

FIG. 6.—Inside of a right shell valve. The division of the adductor muscle into a large anterior and a small posterior portion is conspicuously shown by the scar on this valve. Two-thirds natural size.

PLATE 4.

FIG. 7.—Inside of the right shell valve of a specimen that has been rather badly attacked by boring sponges. The roughenings on the surface seem to cover the deep borings of the sponge. Two-thirds natural size.

FIG. 8.—Ventral view of the foot showing the split end and the opening of the byssal gland. Magnified three diameters.

PLATE 5.

FIG. 9.—Outer surface of the left lobe of the mantle showing the arrangement of blood vessels. Two-thirds natural size.

FIG. 10.—Animal as seen from the left side with the left shell valve and mantle lobe removed. The rounded bodies at the bases of the marginal row of tentacles are the eyes. Two-thirds natural size.

PLATE 6.

FIG. 11.—Animal as seen from the left side with the left shell valve and mantle lobe removed and with a portion of the pericardial wall cut away. A few of the blood vessels are shown. Two-thirds natural size.

FIG. 12.—Animal as seen from the left side with the left shell valve and mantle lobe removed, with the alimentary canal shown. Two-thirds natural size.

PLATE 7.

FIG. 13.—Animal as seen from the left side with the left shell valve and mantle lobe removed. Drawn to show the arterial system of blood vessels. Two-thirds natural size.

FIG. 14.—Animal as seen from the left side with the left shell valve and mantle lobe removed. Drawn to show the systemic veins. Two-thirds natural size.

PLATE 8.

FIG. 15.—Animal as seen from the left side with the left shell valve and mantle lobe removed. Drawn to show the nervous system. Two-thirds natural size.

FIG. 16.—Inner surface of the right lobe of the mantle showing the arrangement of the pallial muscles. Two-thirds natural size.

PLATE 9.

FIG. 17.—A portion of a gill showing the arrangement of parts. The figure indicates the inter-lamellar junctions cut at different levels. The further lamella is the one that was attached to the suspensory membrane and the vessel (ba′) was directly connected with the vessel that supplied the gill with blood (ba, Fig. 11). This vessel follows along the edge of the inter-lamellar junction to the free edge of the unattached lamella, (the one on the side nearest the observer in the figure) where it bends back and passes down the modified

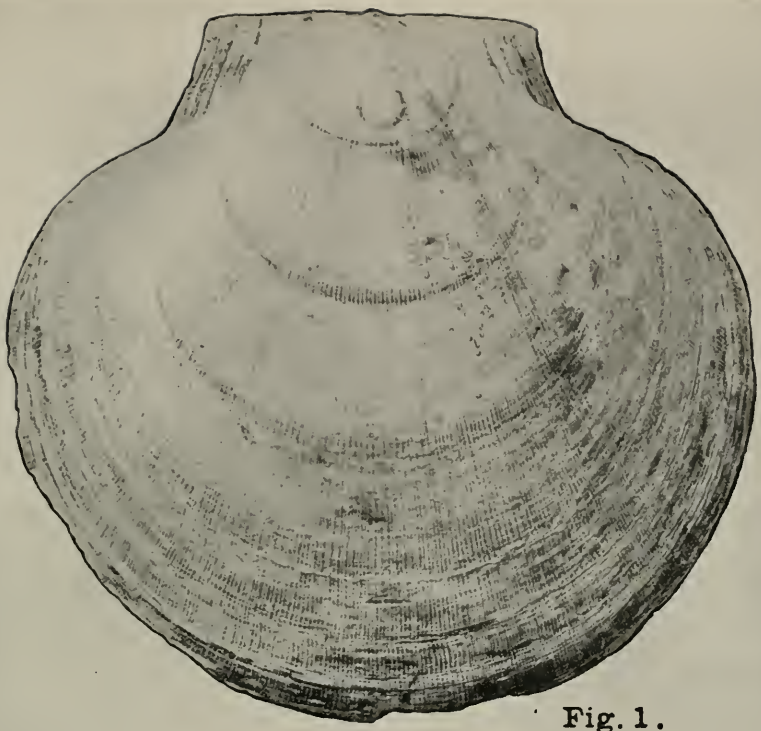

Fig. 1.

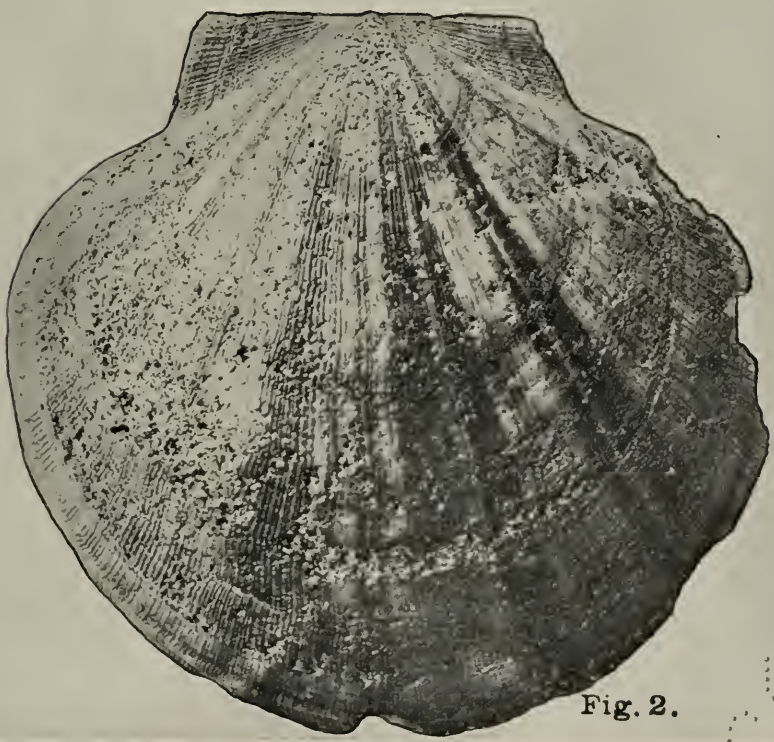

Fig. 2.

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PLATE I.

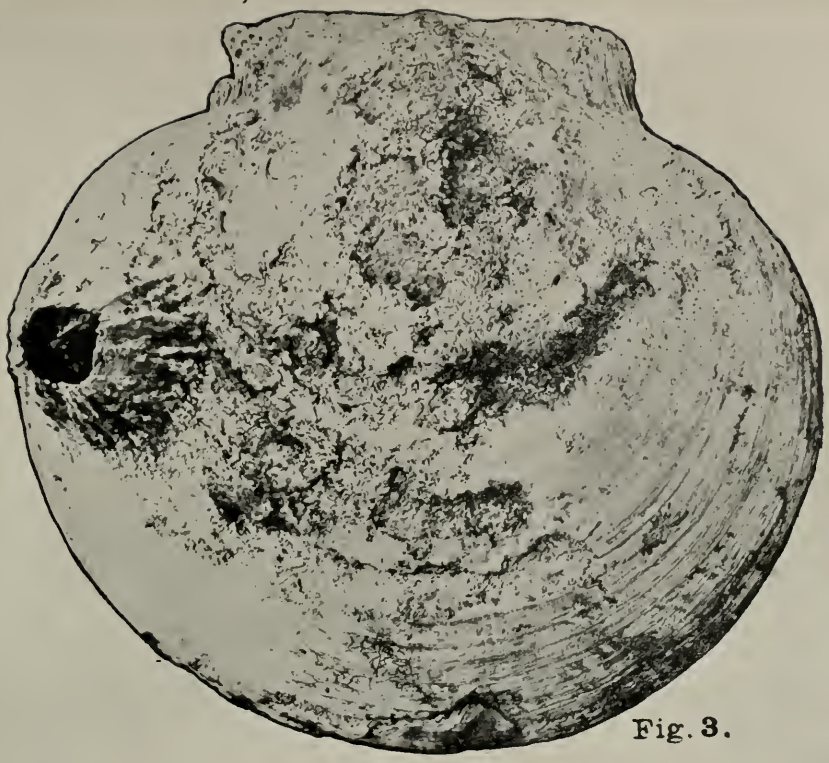

Fig. 3.

Fig. 4.

PLATE 2.

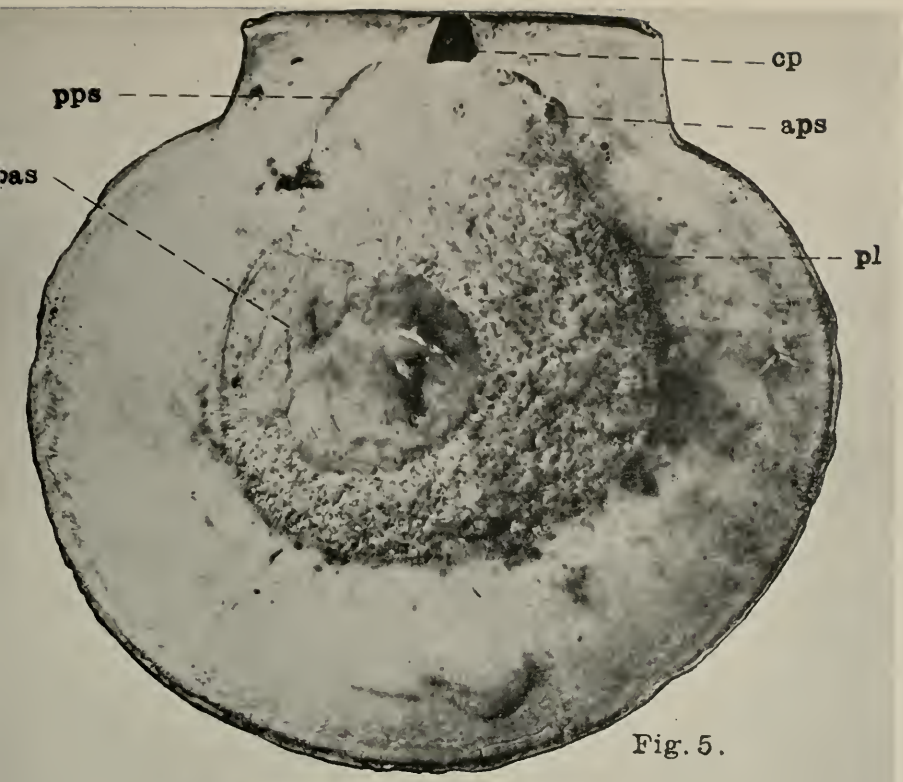

Fig. 5.

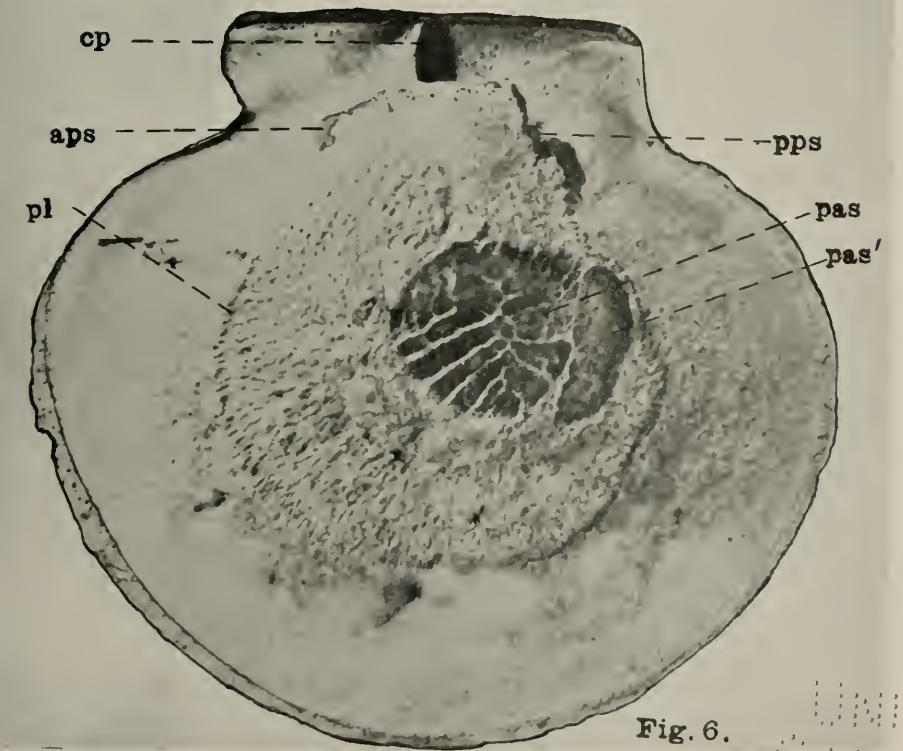

Fig. 6.

PLATE 3.

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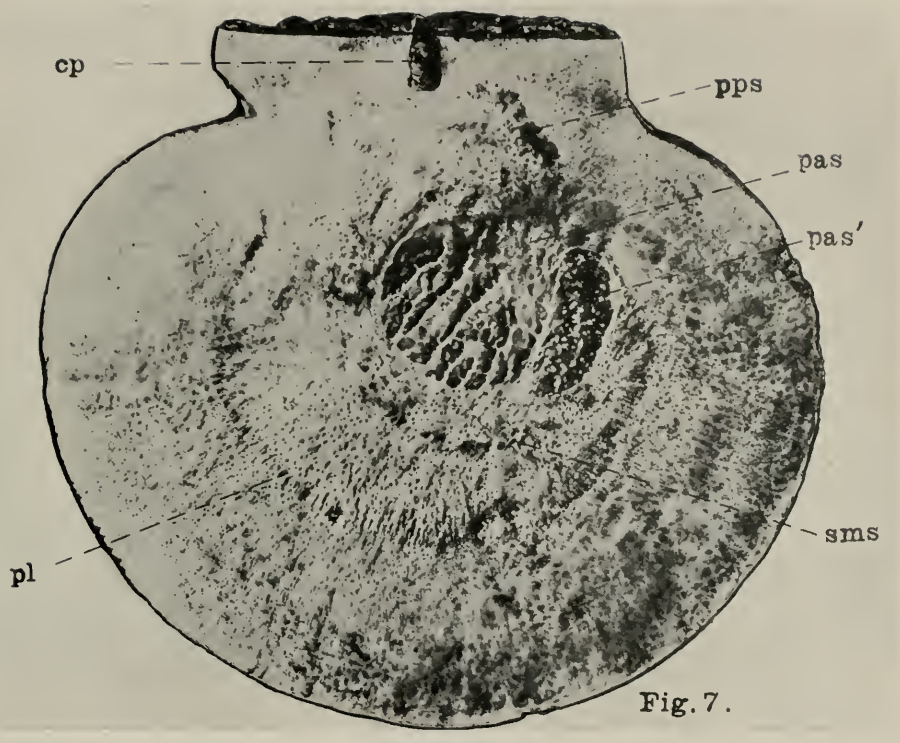

Fig. 7.

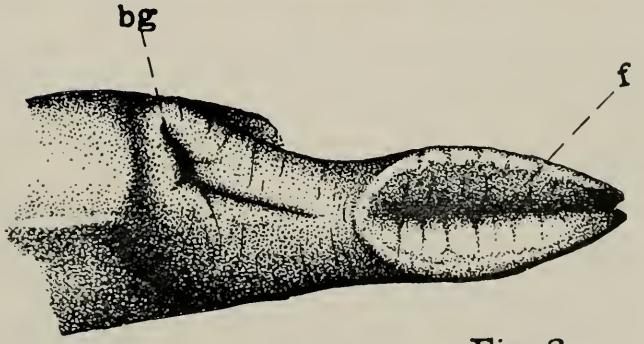

Fig. 8.

PLATE 4.

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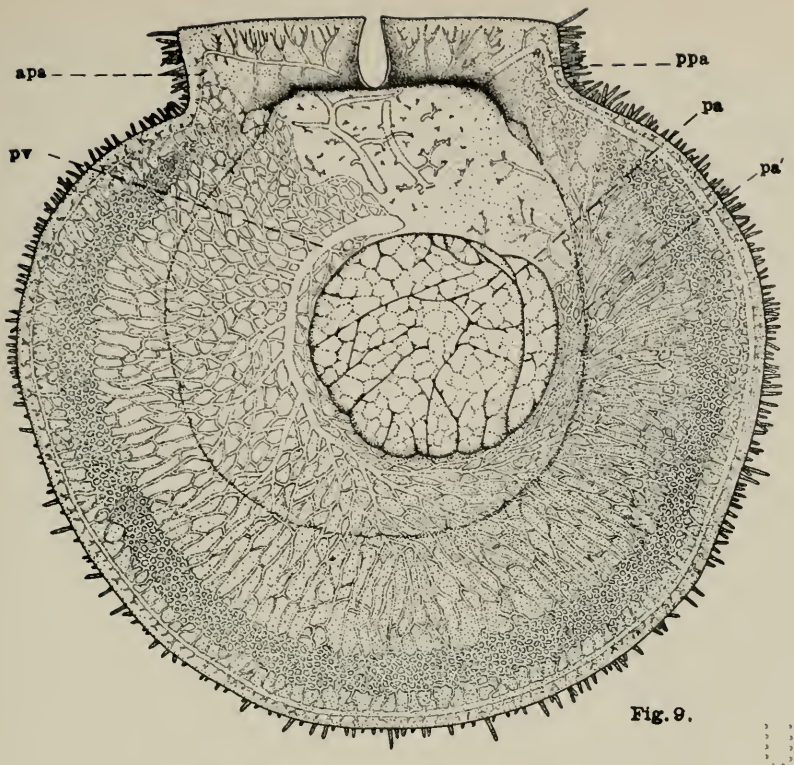

Fig. 9.

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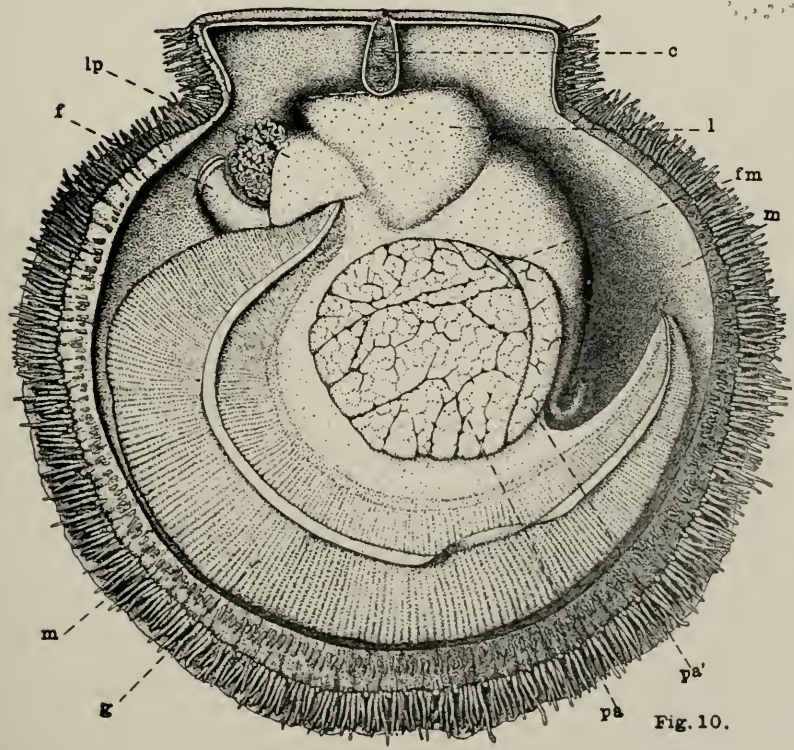

Fig. 10.

Drew del.

PLATE 5.

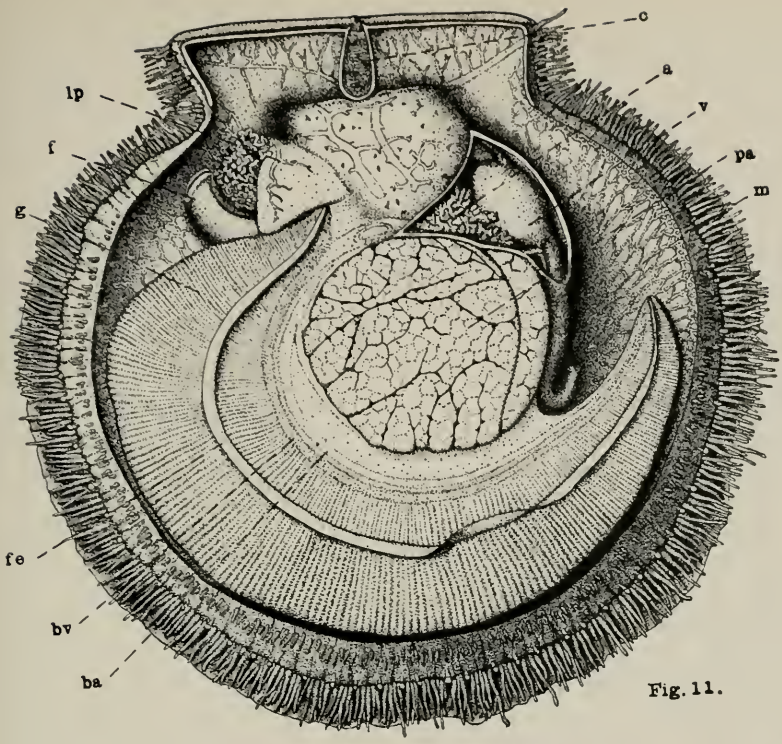

Fig. 11.

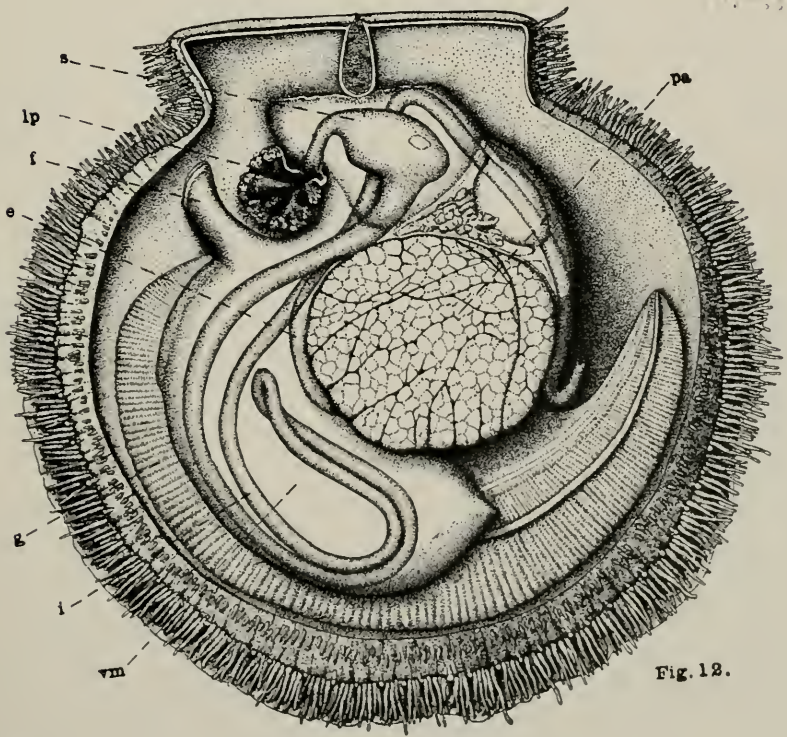

Fig. 12.

Drew del.

PLATE 6.

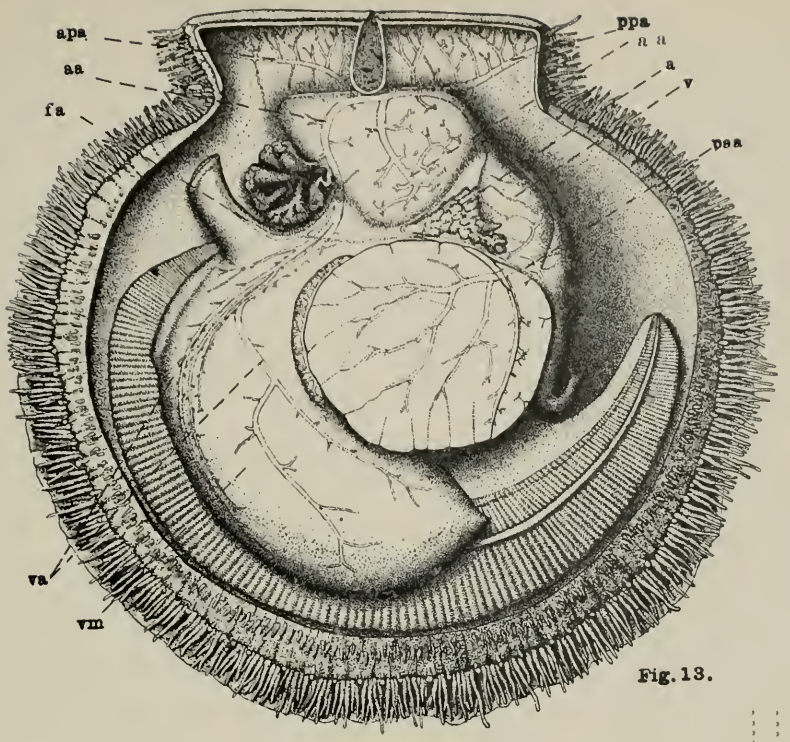

Fig. 13.

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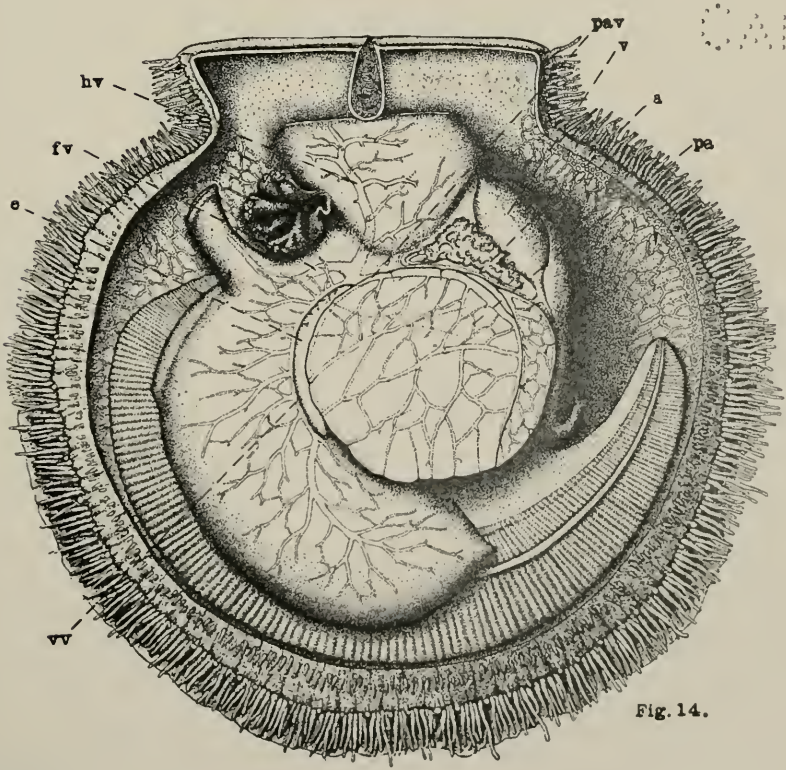


Fig. 14.

Drew del.

PLATE 7.

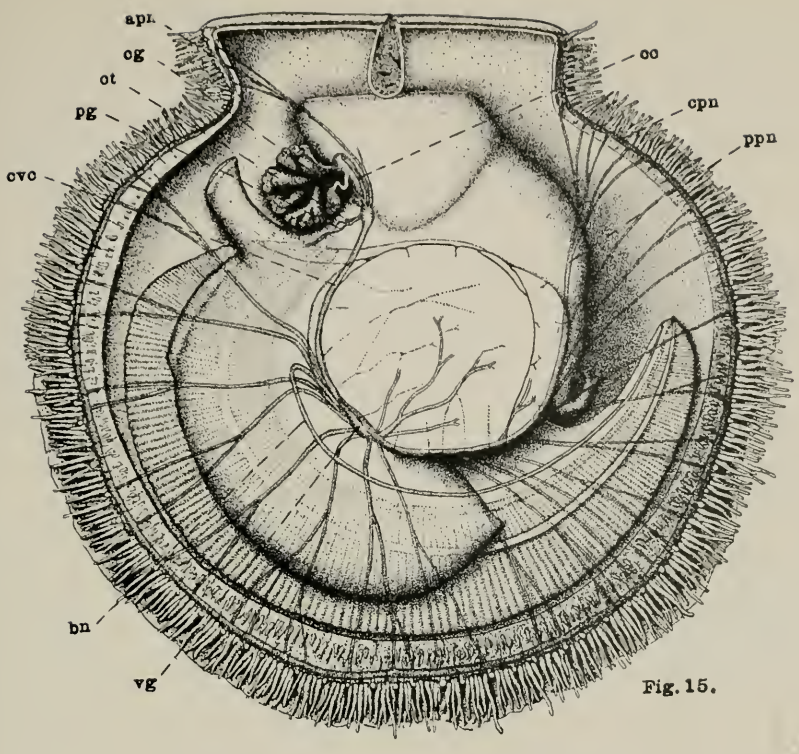


Fig. 15.

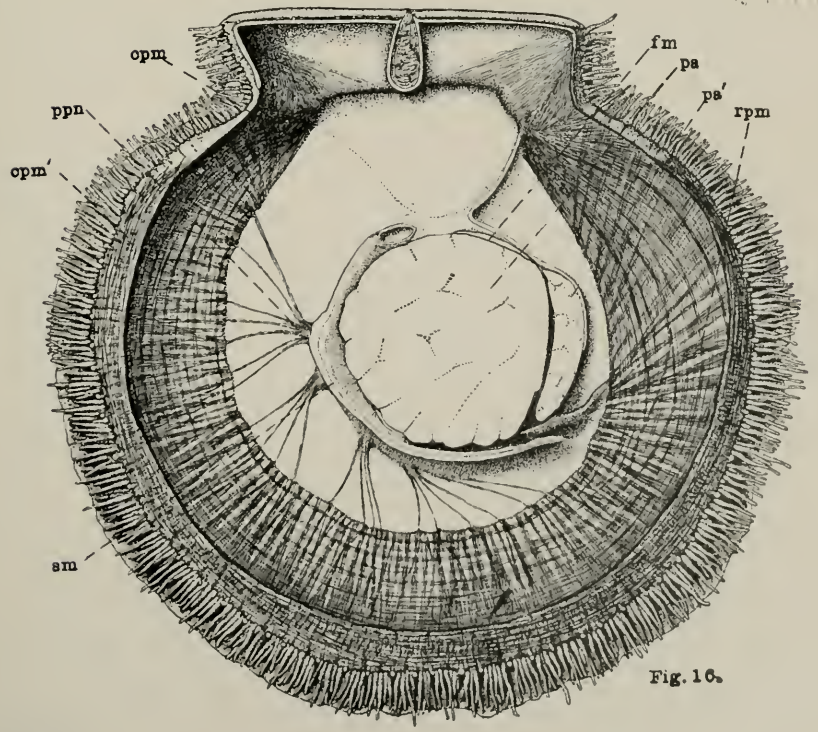


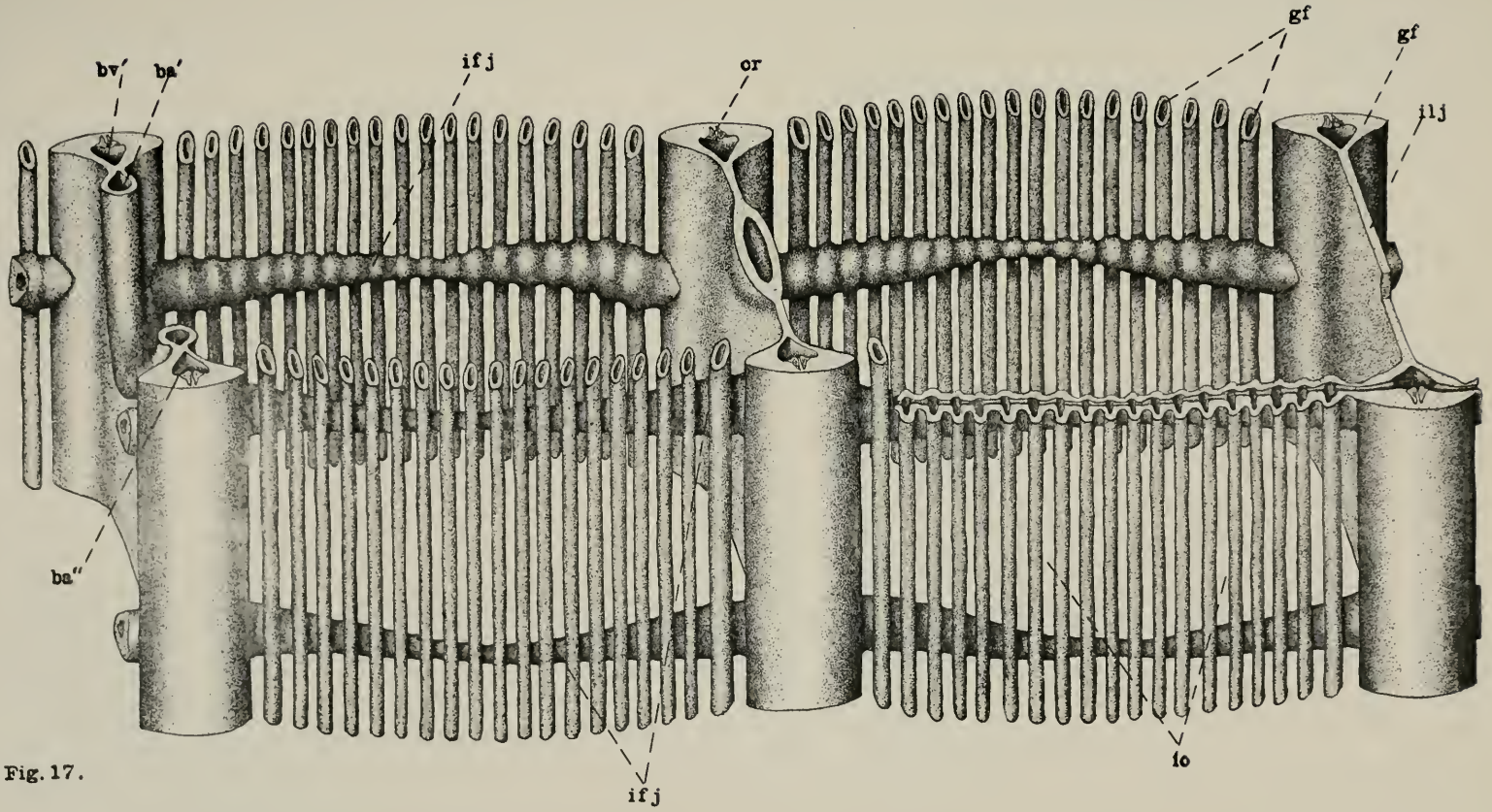
Fig. 16.

Drew del.

PLATE 8.

Drew del.

PLATE 9.



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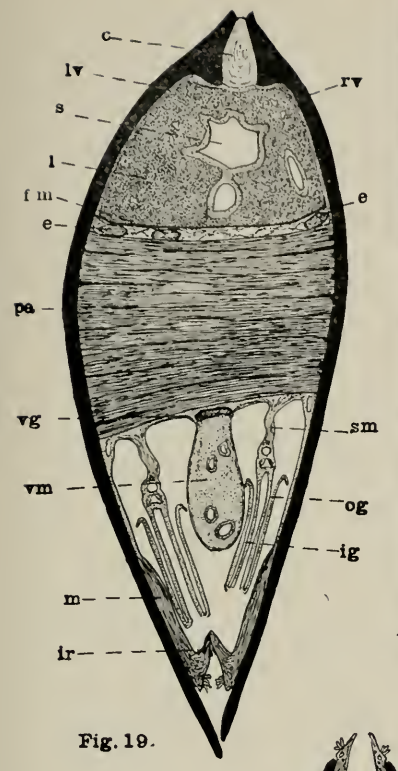

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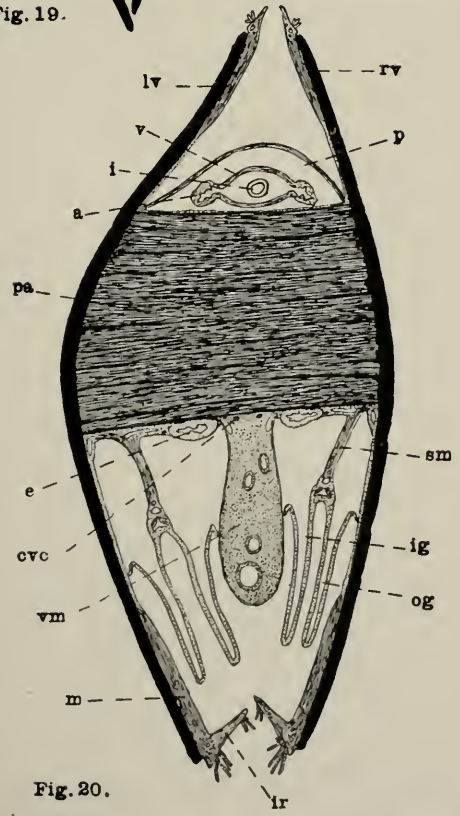

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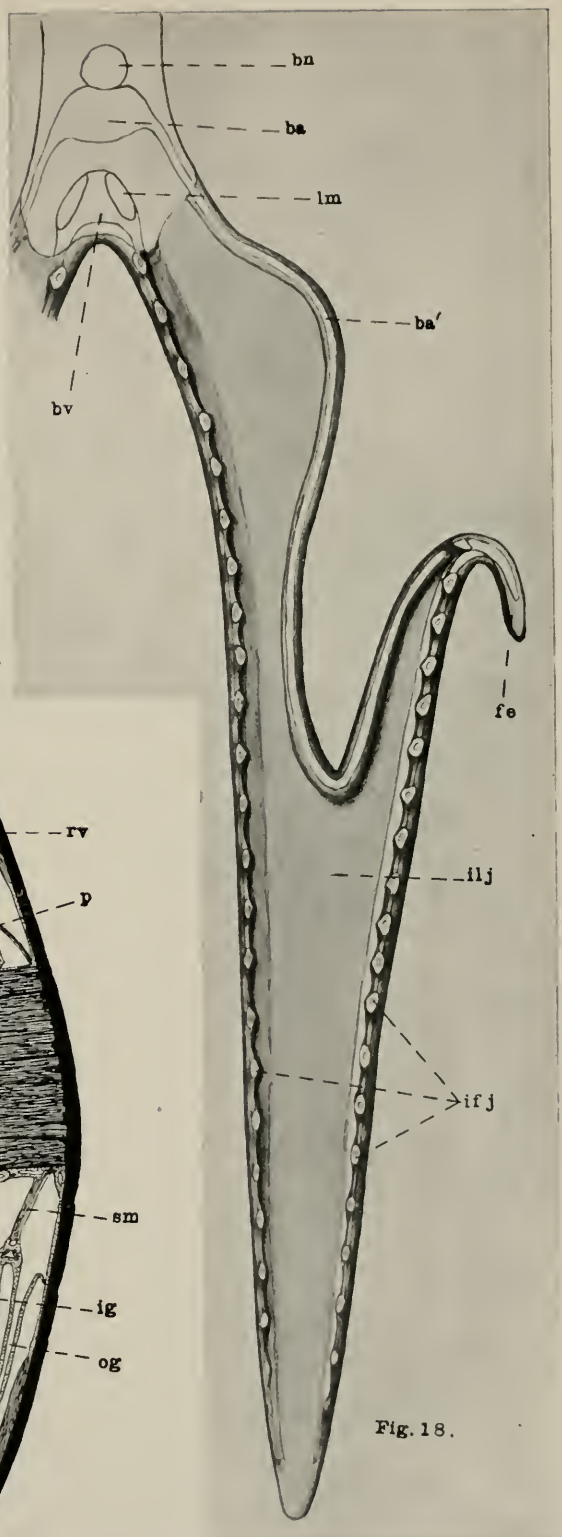

Fig. 18.

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PLATE 10.

Drew del.

PLATE II.

Fig. 21.

Fig. 22.

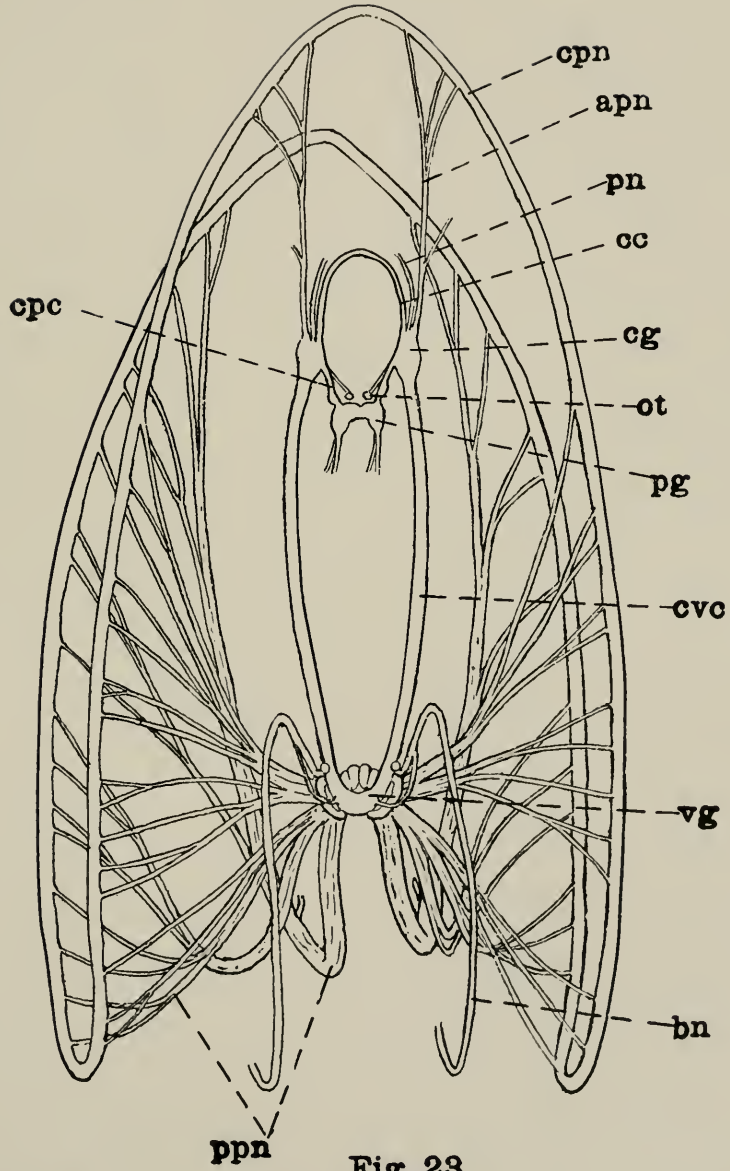

Fig. 23.

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PLATE 12.

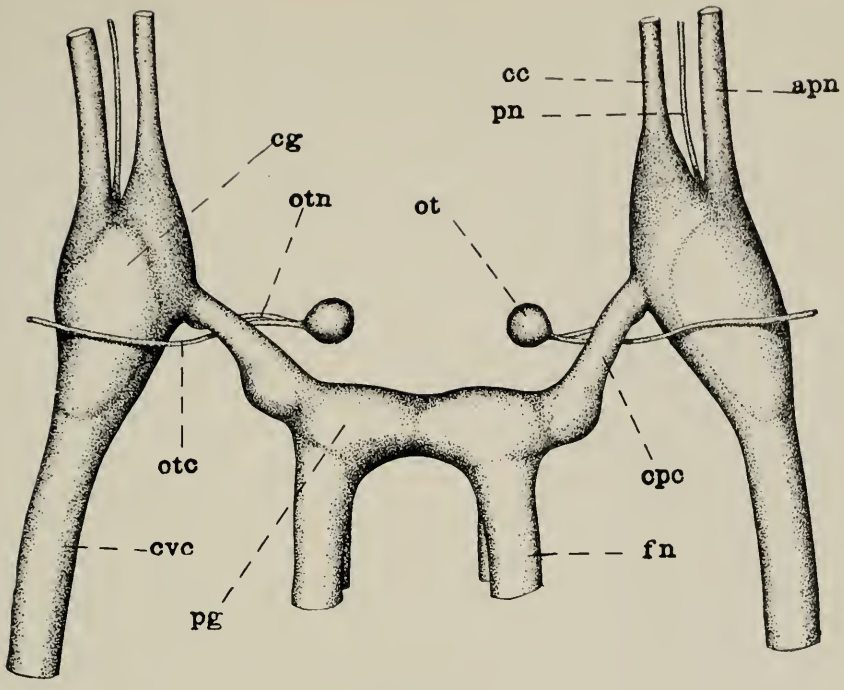

Fig. 24.

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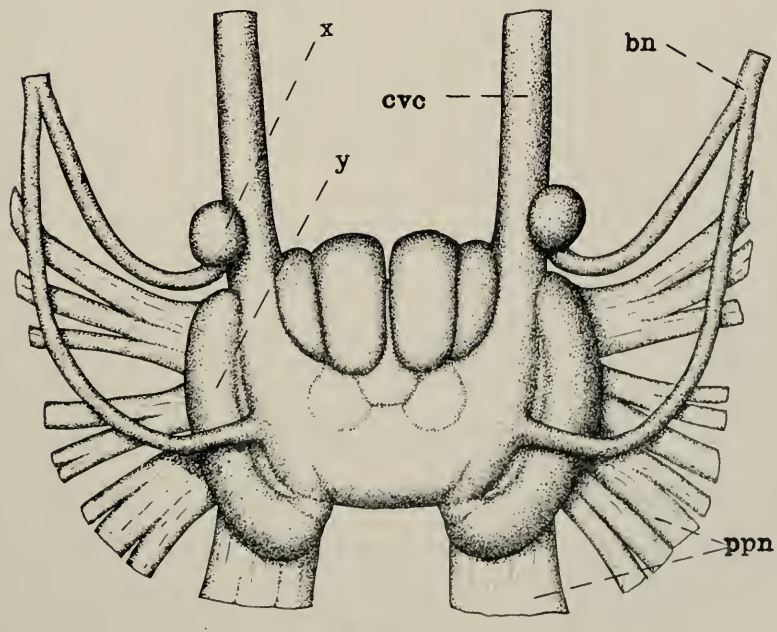

Fig. 25.

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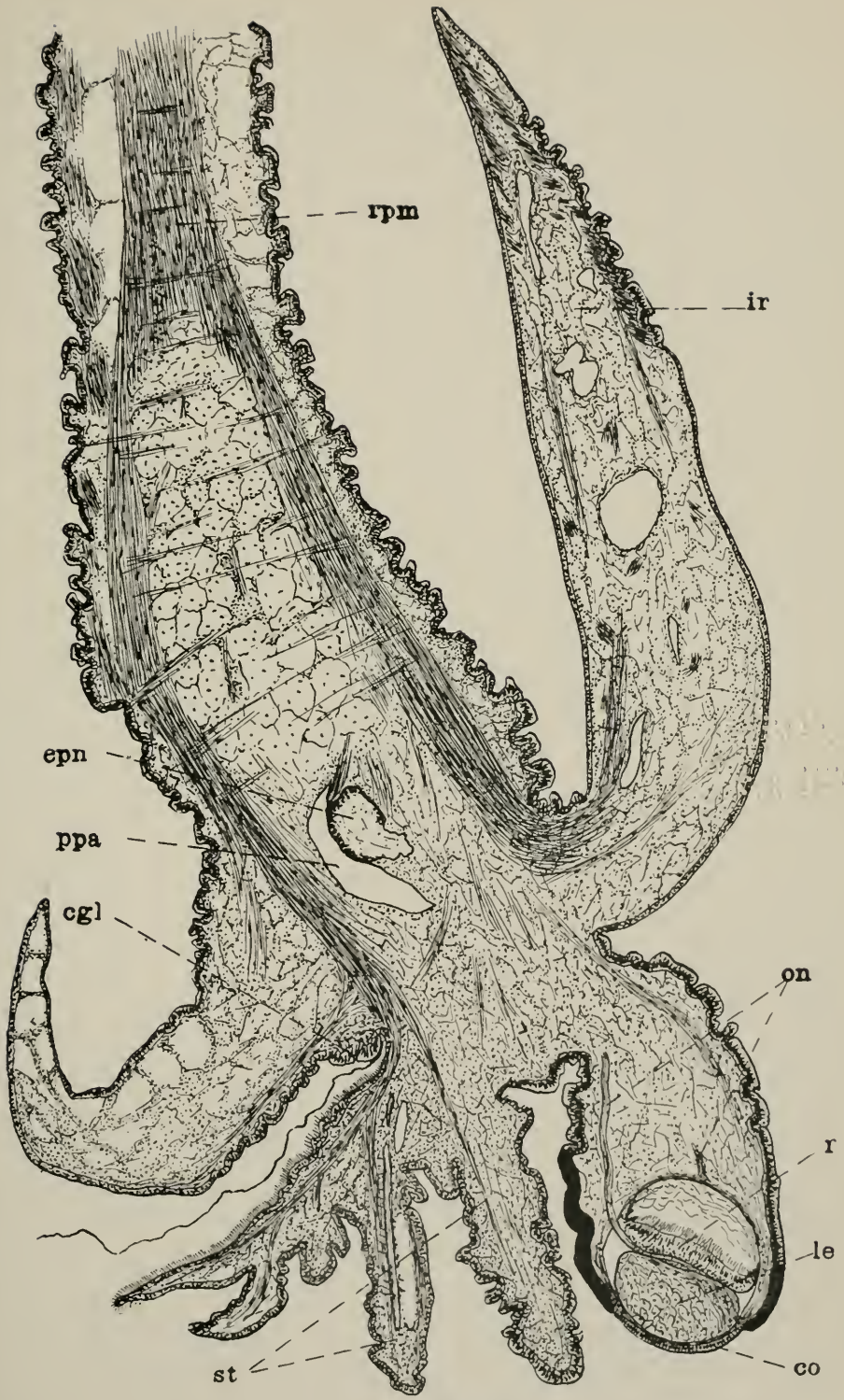

Fig. 26.

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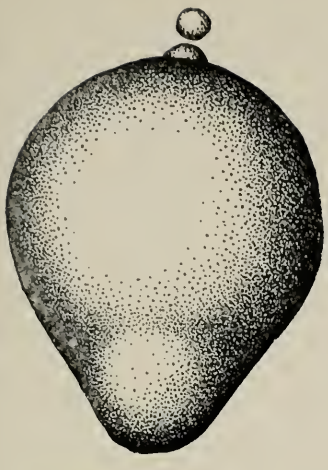
PLATE 14.



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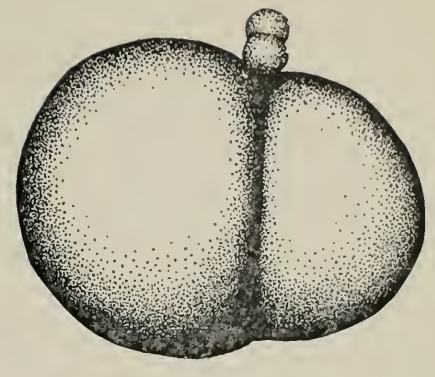

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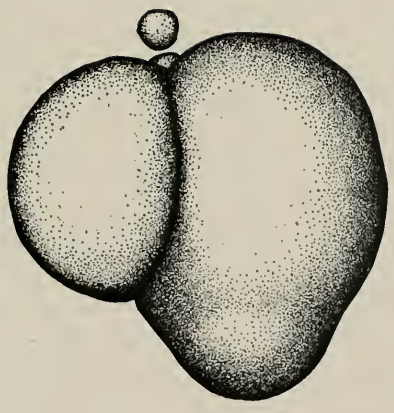

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Fig. 29.

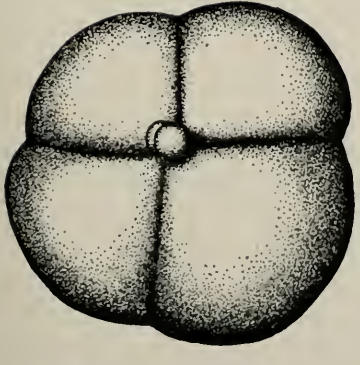

Fig. 30.

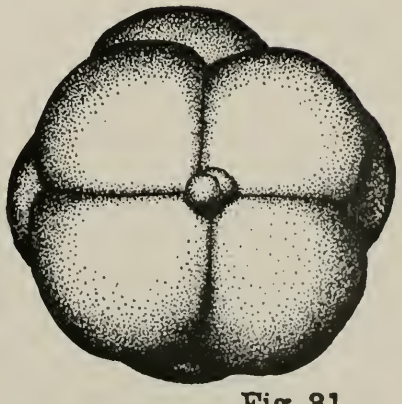

Fig. 31.

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PLATE 15.

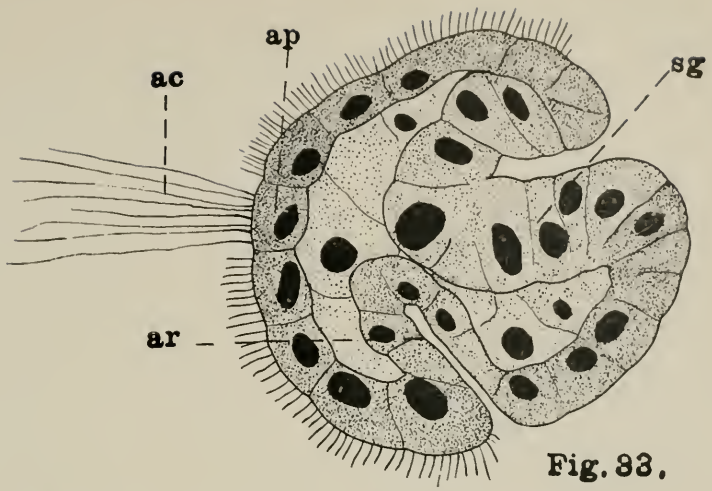
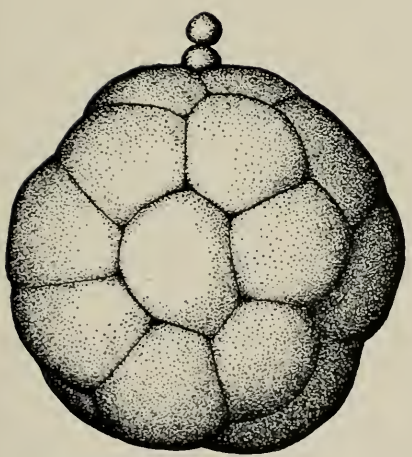


Fig. 33.



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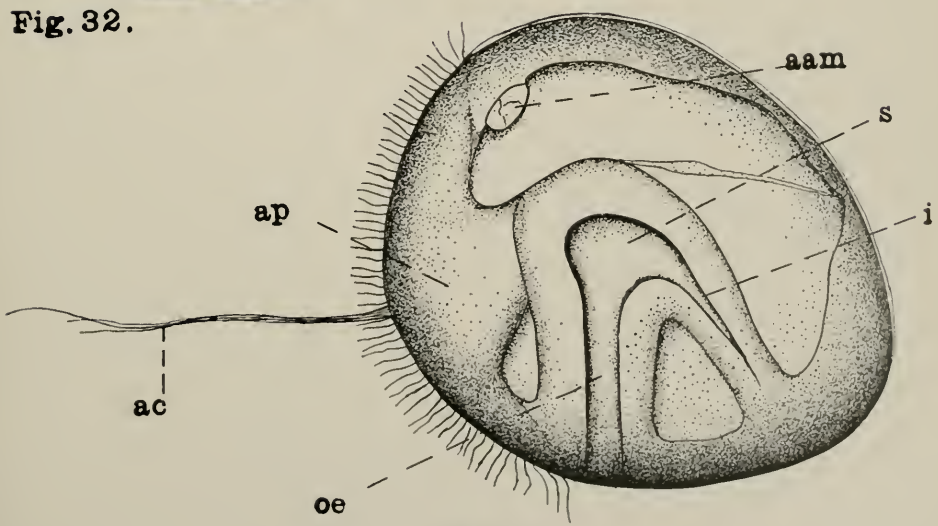

Fig. 34.

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PLATE 16.

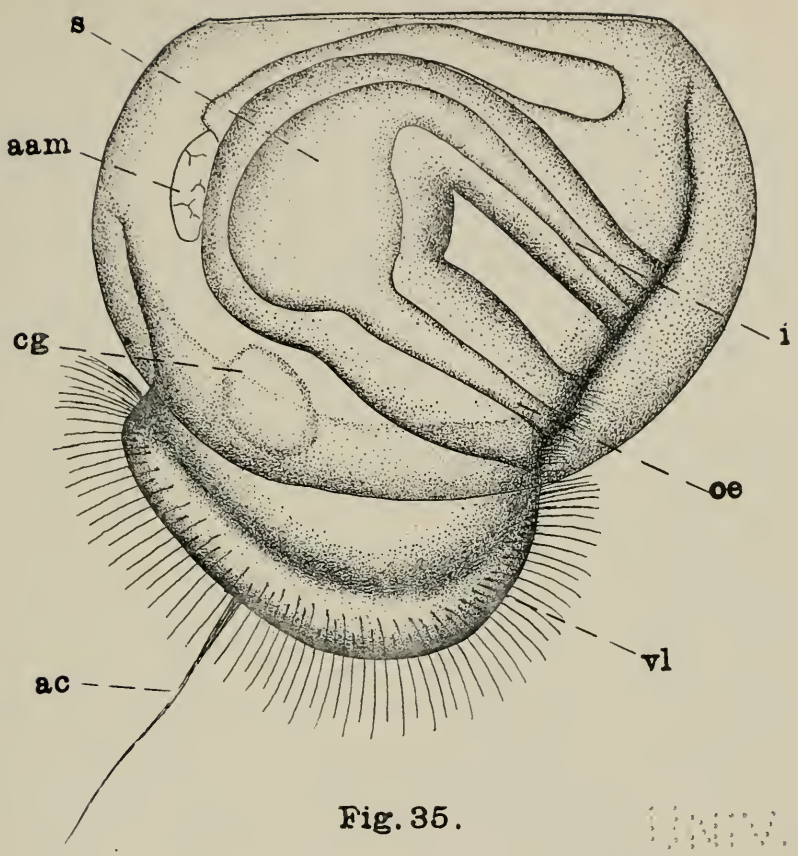

Fig. 35.

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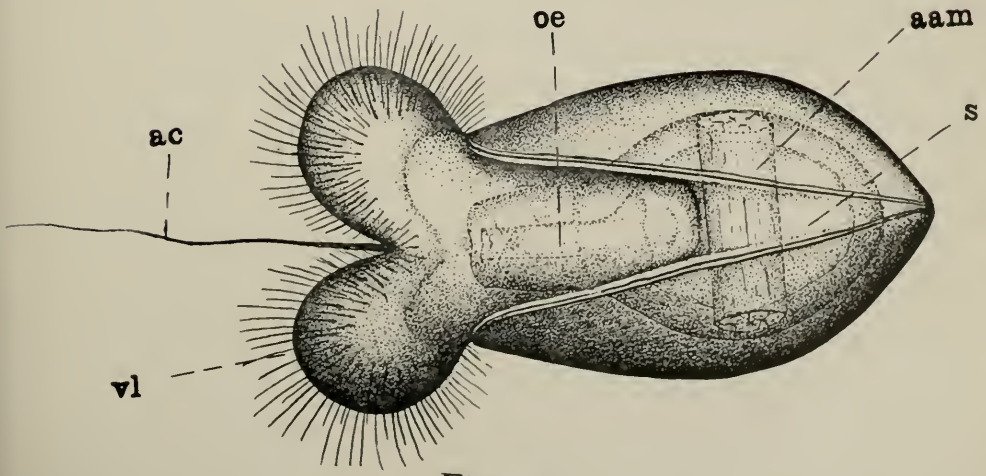

Fig. 36.

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PLATE 17.

The University of Maine
Studies

No. 7

Meteorological Conditions

AT

Orono, Maine

BY

JAMES STACY STEVENS

Professor of Physics

ORONO, MAINE

February, 1907

The University of Maine
Studies

No. 7

Meteorological Conditions

AT

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Professor of Physics

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INTRODUCTION.

The present number of the UNIVERSITY OF MAINE STUDIES is a compilation from various sources. From January 1, 1869, to January 1, 1893, a series of meteorological records was kept at Orono, Maine, by Dr. M. C. Fernald, ex-president and sometime professor of physics at the University of Maine. Since that time the records have been continued by Drs. W. H. Jordan and C. D. Woods, former and present directors of the Maine Agricultural Experiment Station. These results have been averaged and tabulated by the author and are discussed in this paper.

A series of observations on precipitation has been carried on by Prof. H. S. Boardman, of the department of civil engineering, from 1900 to 1906 inclusive, and the results of these observations are printed here.

The work bearing upon the evaporation of snow and ice, and of liquids, was performed in the department of physics by Mr. F. C. Mitchell and Miss M. C. Rice. The matter used here is reprinted from the *Monthly Weather Review*.

Acknowledgment should be made to Prof. L. H. Merrill of the Experiment Station, and to Mr. S. L. Boardman of the Bangor *Commercial* for data supplied to the author; and to various students of the University for clerical work.

BAROMETRY.

The instrument used in the earlier period of these observations was made by J. S. F. Huddleston of Boston, Mass. It was twice compared with a standard instrument, and the error was regarded as small enough to be negligible, but was considered when making the observation. In later years the barometer used was one manufactured by James Green of New York City. It had an error of 0.003, and this error was always considered in recording. Recent standardization shows this barometer to have a negligible error. The times of observation was 7 a. m., 2 p. m., and 9 p. m. The altitude above sea level, as determined by means of the spirit level, was 134 feet from January, 1869, to June 11, 1879, and 129 feet from that time to January, 1893; during the remainder of the period to the present time it was 148 feet. The dates of the missing records were as follows: 1869, June and December; 1893, two-thirds of January; 1895, January and December; 1896, January, February, and June. From October, 1899, to 1903, inclusive, observations were made at 2 p. m. only. The latitude of the place of observation was 44° 54′ 2″ N., and the longitude 68° 40′ 11″ W.

The means published herewith have been reduced to the standard instrumental temperature. The latitude is 44° 54′ north and altitude small; therefore the gravity corrections may be neglected as being probably zero. The observations have been reduced to sea level by the formulæ and tables given in the Weather Bureau Instructions to Voluntary Observers. In order to take annual and other means I have thought it best to give in italics the best values I could obtain by interpolation

between the months contiguous to those for which the data were fragmentary or missing. The means depend in part, therefore, upon graphic interpolations, using the monthly charts of the *Monthly Weather Review* for that purpose. The year 1896 was rejected in taking the average.

The figures are the hundredths of an inch and range from 29.54 to 30.12. The figures in italics in Table 1 imply that a number of observations were missing.

TABLE I.—*Monthly and annual barometric pressure at Orono, Me., reduced to sea level and standard gravity.*

	January.				February.				March.				April.			
	7 a.	2 p.	9 p.	Mn	7 a.	2 p.	9 p.	Mn	7 a.	2 p.	9 p.	Mn	7 a.	2 p.	9 p.	Mn
1869	79	74	77	77	73	69	70	71	85	81	82	83	68	64	67	66
1870	93	90	91	91	72	68	68	69	76	74	77	76	87	84	84	85
1871	00	01	98	99	79	76	75	77	82	75	79	79	73	70	67	70
1872	73	69	72	71	74	69	70	71	72	68	68	70	75	72	73	73
1873	88	86	90	88	72	68	68	69	68	67	68	68	70	70	72	72
1874	02	98	97	99	95	91	93	93	69	63	63	65	80	74	75	76
1875	98	92	90	94	80	78	77	78	92	87	91	91	77	72	74	75
1876	87	83	88	86	86	81	85	83	82	77	79	79	78	73	79	76
1877	88	85	89	88	80	76	78	78	84	79	83	82	86	83	84	84
1878	84	83	87	85	80	77	78	79	75	74	75	75	74	72	74	73
1879	75	71	72	73	80	78	83	80	99	93	91	94	70	66	70	69
1880	03	93	03	00	90	85	88	89	91	82	89	88	83	75	79	79
1881	95	91	92	93	02	93	98	98	59	57	59	58	65	59	64	63
1882	91	87	96	91	94	91	98	93	92	87	91	90	88	83	84	85
1883	06	01	02	03	05	00	05	03	77	73	73	75	89	84	88	87
1884	98	94	93	95	00	92	94	96	89	85	86	86	70	69	71	70
1885	91	87	80	86	80	77	77	78	86	83	85	85	89	85	85	87
1886	93	92	95	93	86	83	83	84	77	74	74	75	05	01	02	03
1887	88	90	87	88	06	01	02	03	76	71	74	74	88	82	83	84
1888	93	87	89	90	93	89	94	92	85	80	86	84	95	91	95	94
1889	87	84	85	85	91	86	93	90	75	71	72	73	87	83	85	85
1890	05	98	98	00	95	92	97	95	84	79	82	82	96	90	91	92
1891	90	86	89	88	92	89	92	90	02	98	00	00	82	77	80	80
1892	90	85	88	88	02	98	03	01	75	71	75	73	84	78	82	82
1893	95	90	92	92	93	87	89	89	91	86	89	89	95	91	93	93
1894	00	98	98	98	98	92	97	96	92	87	89	89	91	89	89	90
1895	90	86	87	88	73	62	54	63	78	76	74	76	90	86	89	88
1896	..	..	..	..	..	..	..	..	04	98	97	00	04	03	06	04
1897	89	82	89	86	95	87	90	91	89	82	86	86	89	84	88	87
1898	79	75	80	78	91	91	90	91	04	93	01	99	77	71	74	74
1899	87	86	87	87	75	75	77	76	81	74	77	77	87	80	84	84
Mean	91	87	89	89	88	83	86	86	83	78	81	81	83	80	80	81

TABLE I.—*Continued.*

	May.				June.				July.				August.			
	7 a.	2 p.	9 p.	Mn	7 a.	2 p.	9 p.	Mn	7 a.	2 p.	9 p.	Mn	7 a.	2 p.	9 p.	Mn
1869	65	61	63	63	70	66	70	69	75	72	74	74	84	81	81	82
1870	81	77	79	79	84	80	80	81	78	74	75	76	83	79	80	81
1871	69	76	71	72	74	69	71	71	78	74	77	77	81	77	78	79
1872	75	74	74	75	79	77	76	77	79	72	72	74	85	80	81	82
1873	83	80	79	80	80	75	76	77	32	79	80	80	90	87	87	88
1874	73	70	69	71	71	68	67	69	82	80	79	80	85	80	82	83
1875	79	75	75	77	82	78	82	81	78	76	76	77	91	88	89	89
1876	84	80	84	82	84	81	84	83	79	76	78	78	89	85	87	87
1877	77	74	76	75	78	79	79	79	79	76	76	77	82	79	80	80
1878	78	74	77	76	80	77	78	78	83	88	83	84	76	74	75	75
1879	82	87	94	88	79	76	78	77	81	78	79	79	80	76	78	77
1880	87	84	87	86	84	80	82	82	80	78	79	79	91	87	89	89
1881	98	94	95	96	78	74	76	76	79	75	77	77	87	83	85	85
1882	92	86	88	89	73	68	70	70	86	82	84	84	91	86	88	89
1883	90	84	86	87	88	85	85	86	82	79	80	81	89	85	87	87
1884	82	79	81	81	98	92	91	94	71	68	66	68	94	92	93	93
1885	93	88	90	90	83	79	79	81	85	81	83	83	88	86	85	86
1886	82	78	79	80	87	83	85	85	85	81	81	83	86	84	84	85
1887	97	93	92	94	95	92	91	93	87	84	85	85	88	85	86	86
1888	91	87	89	89	78	74	77	76	83	78	80	80	79	77	80	79
1889	83	79	82	81	88	83	85	85	85	83	83	84	93	90	91	92
1890	87	83	84	85	84	81	83	82	89	85	86	87	87	84	86	85
1891	89	85	88	87	82	79	80	80	88	86	87	87	90	86	88	88
1892	86	82	85	84	86	82	82	84	88	86	86	86	91	88	89	89
1893	78	74	75	76	92	90	90	91	76	77	74	75	83	80	79	81
1894	88	81	86	85	82	78	78	79	85	80	82	82	88	84	86	86
1895	85	85	87	86	95	93	89	92	85	89	84	86	84	91	88	88
1896	98	99	96	98	..	..	..	..	96	93	94	94	00	97	94	97
1897	84	78	80	81	77	70	82	77	84	82	83	83	79	76	77	77
1898	83	77	79	80	80	76	79	78	88	83	85	85	81	77	79	79
1899	86	81	83	83	81	77	80	79	77	73	76	75	85	81	84	83
Mean.....	89	88	89	89	81	79	79	80	82	79	80	80	86	83	84	84

TABLE I.—*Concluded.*

	September.				October.				November.				December.			
	7 a.	2 p.	9 p.	Mn	7 a.	2 p.	9 p.	Mn	7 a.	2 p.	9 p.	Mn	7 a.	2 p.	9 p.	Mn
1869	00	96	98	98	76	73	77	75	76	72	74	74	75	70	68	68
1870	95	92	93	93	88	82	83	84	71	68	72	70	67	64	65	65
1871	91	87	88	89	86	87	84	86	73	73	73	73	79	78	80	79
1872	85	82	82	83	89	87	87	88	81	77	78	79	82	81	84	82
1873	89	86	85	86	92	82	86	86	65	70	71	69	90	89	89	89
1874	94	88	92	92	87	84	84	85	95	90	90	92	91	85	91	89
1875	83	77	79	79	80	79	80	80	82	82	81	81	79	75	76	77
1876	84	82	83	83	78	71	73	76	83	79	81	81	69	70	72	70
1877	90	85	88	88	93	88	88	89	96	93	94	94	95	92	94	94
1878	02	99	01	01	87	84	84	85	74	72	74	73	80	77	80	79
1879	99	95	96	96	92	88	91	90	94	90	93	92	02	00	04	03
1880	86	85	87	86	93	89	91	91	01	00	01	01	80	78	79	79
881	00	96	98	98	95	95	96	95	98	94	95	96	00	96	97	98
1882	97	94	96	96	01	94	95	97	98	95	95	96	89	85	89	88
1883	95	91	93	93	06	03	05	05	94	93	95	94	97	91	92	93
1884	95	90	93	93	97	92	95	95	88	87	89	88	01	98	97	99
1885	89	87	89	88	96	92	93	93	82	80	81	81	78	78	80	79
1886	03	94	98	98	08	03	05	05	82	82	82	82	97	94	98	96
1887	96	93	97	95	88	83	85	85	88	79	88	85	94	91	94	93
1888	98	94	95	96	76	73	77	75	98	95	96	96	77	74	77	76
1889	95	91	92	93	92	89	92	91	92	88	91	90	97	93	97	96
1890	01	99	99	00	78	74	76	76	85	83	86	85	85	84	89	86
1891	02	98	98	99	93	88	91	91	02	99	03	02	94	90	94	93
1892	01	97	00	00	77	73	76	75	92	89	91	91	82	75	80	79
1893	87	88	90	88	01	92	96	96	02	97	90	96	93	89	97	92
1894	00	06	93	99	92	82	89	88	96	81	84	87	90	03	02	98
1895	92	87	84	87	80	81	87	83	00	00	00	00	95	98	99	97
1896	03	99	00	00	93	94	96	94	12	10	11	11	03	05	06	05
1897	93	86	90	90	99	93	93	95	86	82	84	84	87	85	84	85
1898	85	81	82	83	93	89	93	92	84	78	81	81	77	75	79	77
1899	89	86	87	87	06	04	05	05	83	80	81	81	86	84	86	86
Mean	94	90	91	92	87	83	85	85	88	85	87	87	87	85	87	86

TABLE 2.—*Monthly and annual barometric pressure at 2 p. m. at Orono, Me.*

		Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1900.....	75	77	71	72	74	72	72	92	85	98	82	81
1901.....	75	50	71	.....	.....	.....	.....	.....	85	87	72	83
1902.....	82	58	76	71	77	65	79	74	92	82	84	84
1903.....	68	73	04	70	95	85	67	86	90	85	78	74

The maximum barometric pressure reduced to 32° F. was 30.833 inches; the minimum, 28.423 inches;; and the mean, 29.842 inches. The correction for gravity is inappreciable.

THERMOMETRY.

Temperature observations began to be made by Dr. M. C. Fernald, January 1, 1869. From this date to January 1, 1893, observations were made three times a day, at 7 a. m., 2 p. m., and 9 p. m. In Table 3 the mean of these observations is found by assigning to the 9 p. m. observations a double weight. Beginning with 1893 the maximum and minimum temperature for each 24 hours were recorded. Table 4 shows the maximum and minimum for each month. The thermometer used from 1869 to 1893 was a Huddleston, since that time a Green. The location was changed in June, 1879, and about January, 1893.

TABLE 3.—*Monthly mean temperatures at Orono, Me., based on tridaily observations.*

Year.	January.				February.				March.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	Mean.
1869	16.6	23.1	18.8	18.4	16.5	27.3	21.6	21.8	18.5	30.6	23.9	24.2
1870	19.2	27 2	21.9	22.6	14.1	26.3	18.0	19.1	22.0	34.2	27.9	28.0
1871	12.6	18.2	16.0	15.7	15.2	25.8	21.2	21.0	30.5	39.6	34.3	34.7
1872	13.8	20.2	15.9	16.5	9.1	26.1	18.7	18.2	12.6	25.8	19.5	19.4
1873	9.7	20.1	15 1	15.0	8.5	22.8	17.4	16.5	21.5	32.6	27.6	27.4
1874	15.3	23.6	19.0	19.2	11.5	23.5	17.5	17.5	22.1	33.2	27.4	27.5
1875	1.1	14.6	9.0	8.4	8.1	18.9	13.5	13.5	18.2	30.4	24.9	24.6
1876	14.5	23.6	18.0	18.5	14.3	24.4	18.2	18.8	22.3	33.2	28.5	28.1
1877	2.8	16.3	9.1	9.3	19.8	31.8	26.1	25.9	24.2	34.1	27.7	28.4
1878	13.1	22.6	16.9	17.4	14.4	30.2	23.1	22.7	27.8	37.3	33.3	32.9
1879	8.1	19.8	13.3	15.6	8.1	23.1	16.8	16.2	21.9	33.4	28.1	27.9
1880	13.5	28.7	21.6	21.4	17.2	28.6	22.8	22 9	20.6	31.6	26.3	26.2
1881	8.7	20.0	12.7	12.2	16.8	28.4	22.9	22.8	30.9	36.2	34.1	33.8
1882	10.7	22.6	16.3	16.5	14.8	28.8	21.9	22.0	23.3	34.3	29.6	29.2
1883	4.1	17.4	11.7	11.2	11.3	23.7	17.2	17.4	15.7	27.7	21.5	21.6
1884	5.2	19.0	14.4	13.3	18.0	27.5	22.2	22.5	20.2	33.2	27.4	27.1
1885	11.1	21.2	15.6	15.9	3.0	21.4	15.3	13.8	11.3	26.6	19.3	19.1
1886	13.9	22.6	18.1	18.2	11.9	23.7	19.5	18.7	20.4	33.1	27.8	27.3
1887	9.5	18.4	14.4	14.2	12.3	22.8	17.1	17.4	20.7	32.3	25.3	25.9
1888	4.7	14.7	8.4	9.1	12.7	25.0	19.5	19.2	22.6	32.6	28.2	27.9
1889	20.6	28.6	24.9	24.8	9.5	19.0	16.1	15.2	27.7	39.5	33.0	33.3
1890	11.9	21.7	18.3	17.6	18.7	28.0	22.1	22.7	22.9	34.9	29.0	28.9
1891	15.8	25.6	20.9	20.8	19.4	27.7	22.7	23.1	23 9	34.9	28.3	28.9
1892	18.0	26.4	22.2	22.2	15.4	30.1	22.5	22.6	20.1	33.3	27.7	27.2
Mean	11.4	21.5	16.4	16.5	13.2	25.6	19.7	19.5	21.3	33.1	27.5	27.9

Year.	April.				May.				June.			
1869	35.3	45.1	32.2	39.2	45.1	59.2	48.8	50.5	.....	.....	.....	.....
1870	37.5	51.9	41.9	43.3	46.9	60.6	48.8	52.0	61.5	74.5	62.0	65.0
1871	36.1	46.8	40.1	40.8	44.9	58.4	48.2	49.9	57.7	70.2	58.6	61.3
1872	34.7	47.4	38.6	39.8	48.7	57.9	49.8	51.6	59.9	71.6	61.3	63.5
1873	35.4	45.4	37.8	39.1	47.9	61.1	48.7	51.6	55.5	69.2	57.5	59.9
1874	29.0	38.8	32.1	33.0	46.8	59.7	49.1	51.2	65.4	66.7	58.4	59.7
1875	31.7	43.2	34.8	36.1	47.2	59.6	49.5	51.8	56.8	68.9	57.8	60.3
1876	34.5	45.6	37.8	38.8	46.0	58.0	47.8	49.9	60.8	73.6	61.8	64.5
1877	37.4	51.3	41.8	43.1	47.7	61.6	50.5	52.6	60.3	72.0	60.2	63.2
1878	40.4	51.4	42.8	44.4	50.4	61.2	52.4	54.1	57.9	70.7	58.6	61.5
1879	33.5	45.2	37.0	38.2	50.8	65.4	52.7	55.0	57.1	66.0	57.1	59.3
1880	36.1	47.7	38.5	40.2	51.7	55.4	53.9	56.2	60.6	71.0	60.5	63.2
1881	33.3	46.7	39.2	39.6	47.7	59.9	51.5	52.7	54.4	68.1	55.4	58.3
1882	32.2	41.8	35.6	36.3	44.9	57.2	47.7	49.4	59.2	70.1	60.1	62.4
1883	34.5	45.9	37.6	38.9	47.0	59.6	50.5	51.9	62.6	72.3	61.3	64.4
1884	38.7	48.6	41.5	42.6	47.4	57.4	47.7	50.0	60.6	74.5	61.8	64.7
1885	35.8	48.9	39.1	40.7	47.7	61.5	49.3	51.9	58.9	69.6	59.3	61.8
1886	38.3	52.5	41.5	43.5	49.5	62.3	50.9	53.4	59.7	70.0	57.9	61.4
1887	32 3	44.4	36.7	37.5	47.7	64.6	53.0	54.6	59.9	70.9	59.7	62.6
1888	33.1	44.3	36.3	37.5	46.9	59.0	48.8	50.9	60.8	70.2	60.0	62.8
1889	40.2	53.4	43.3	45.1	52.7	66.8	53.0	56.4	62.9	72.5	62.1	64.9
1890	35.3	47.9	38.8	40.2	49.3	59.4	50.6	52.5	57.8	66.6	57.2	59.7
1891	37.7	47.9	40.1	41.4	47.1	60.6	50.2	52.0	57.6	69.1	58.0	60.8
1892	37.8	52.9	41.0	43.2	48.0	58.4	49.9	51.6	58.3	71.7	61.0	63.0
Mean	35.4	47.3	38 8	40.1	47.9	60.2	50.0	52.3	59.0	70.9	59.4	62.1

TABLE 3—*Concluded.*

Year.	July.				August.				September.			
	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	Mean.	7 a. m.	2 p. m.	9 p. m.	Mean.
1869.....	62.0	74.6	63.9	66.1	57.2	70.9	59.8	61.9	54.9	67.7	56.8	59.1
1870.....	64.3	77.7	65.3	68.2	61.1	77.6	63.3	67.6	51.3	66.8	56.0	57.5
1871.....	62.4	75.4	64.0	66.5	59.9	74.7	63.4	65.4	48.0	63.0	52.6	54.1
1872..... ...	64.2	76.9	65.8	68.2	62.7	75.4	64.8	66.9	54.7	64.7	56.7	58.2
1873.....	64.3	76.8	64.3	67.4	58.4	72.4	60.2	65.8	50.1	63.8	52.9	54.9
1874...	62.5	73.5	64.4	66.2	57.7	71.2	60.7	62.6	53.1	66.0	55.9	57.7
1875	52.7	74.6	63.2	65.9	62.3	76.9	65.4	67.5	48.7	61.5	52.3	53.7
1876.....	66.9	75.6	65.7	68.3	61.5	76.8	64.5	66.8	49.4	63.1	52.8	54.5
1877.....	64.0	75.6	65.2	67.5	62.7	75.0	65.0	66.9	52.5	70.1	57.6	59.5
1878.	65.9	75.8	65.8	68.3	61.5	73.6	62.7	65.1	55.3	67.5	57.3	59.4
1879.....	63.9	75.4	63.5	66.6	59.3	73.1	62.3	64.3	52.2	63.7	54.8	56.4
1880.....	65.3	77.6	66.8	69.1	61.0	74.0	63.2	65.4	55.3	68.5	59.1	60.5
1881.....	63.3	73.6	64.5	65.8	64.1	76.1	65.9	68.0	55.8	68.1	59.1	60.5
1882..	67.1	76.4	65.5	68.6	62.2	78.2	65.0	67.9	53.8	63.8	55.1	57.0
1883.....	61.3	71.8	63.6	65.1	60.2	75.0	61.6	64.6	49.7	69.3	54.8	57.2
1884.....	61.8	72.4	62.2	64.7	62.9	74.2	64.2	66.4	53.4	67.6	57.0	58.8
1885.....	65.1	75.2	64.9	67.5	58.9	71.8	61.1	63.2	49.5	63.8	52.5	54.6
1886.....	64.9	75.7	63.9	67.1	58.2	75.0	62.9	64.8	51.1	64.5	54.5	56.2
1887.....	69.0	78 3	68.2	70.9	59.9	71.0	60.9	63.2	49.5	64.5	55.1	56.1
1888.....	62.2	75.0	62.6	65.6	60.1	70.9	61.5	63.5	50.2	62.1	52.3	54.2
1889	63.9	74.8	63.8	66.6	61.2	73.1	62.2	64.7	55.3	67.3	59.3	60.3
1890.....	64.2	74.5	63.1	66.2	61.3	73.3	62.4	64.9	53.9	65.1	56.9	58.2
1891.....	62.7	75.0	61.0	64.9	62.2	73.7	64.3	66.1	55.4	69.0	58.9	60.6
1892.....	63.5	77.6	65.5	68.0	61.3	73.0	64.5	65.8	52.7	67.5	57.0	58.5
Mean	63.6	75.4	64.4	67.0	60.7	74.0	62.9	65.4	53.1	65.8	55.8	57.0

Year.	October.				November.				December.			
1869.....	41.4	52.8	43.4	45.3	28.1	37.0	32.2	32.4	.....	.....	.....	.....
1870.....	42.4	54.4	49.0	48.7	33.8	41.4	34.9	56.3	22.0	28.4	23.4	24.3
1871.....	43.8	54.2	46.4	47.6	25.9	33.6	27.7	28.7	15.1	21.2	15.9	16.5
1872.....	40.8	52.6	43.7	45.2	30.8	37.9	32.7	33.5	9.7	18.3	12.5	14.3
1873.....	41.5	54.9	45.7	47.0	22.1	29.6	23.9	25.0	14.7	25.3	20.3	20.2
1874.....	42.1	55.8	45.9	47.4	28.5	38.1	31.7	32.5	13.5	23.1	18.3	18.3
1875.....	39.9	48.8	42.2	43.3	23.0	31.6	26.9	27.1	13.6	23.5	18.6	18.6
1876.....	38.3	49.2	41.7	42.8	32.2	40.3	34.9	35.8	7.3	20.1	13.0	13.3
1877.....	38.2	49.3	43.4	43.6	34.0	42.7	36.9	37.8	21.4	31.7	26.0	26 3
1878.....	44.5	56.5	48.3	49.4	31.5	38.9	33.0	34.1	21.8	27.8	26.0	25.4
1879...	46.2	57.5	48.4	50.1	30.6	38.2	33.4	33.9	16.2	24.9	18.9	19.7
1880.....	42.5	54.9	45.7	47.2	26.6	37.6	30.5	31.4	14.0	26.2	20.6	20.4
1881.....	43.3	52.6	43.9	45.9	31.7	40.2	35.8	35.9	28.1	34.8	30.1	30.8
1882.....	42.5	57.9	45.1	47.7	30.4	39.7	32.2	33.6	14.1	25.8	19.5	19.7
1883.....	38.5	50.7	41.3	43.0	31.1	40.9	34.0	35.0	16.7	27.2	20.0	21.0
1884.....	39.0	51.9	44.2	44.8	29.3	38.7	33.3	33.7	20.5	28.8	23.0	23.8
1885.....	42.5	53.7	45.3	46.7	32.1	41.6	35.9	36.1	19.1	28.2	23.1	24.4
1886.....	39.1	54.9	44.0	45.5	34.1	42.2	36.9	37.5	14.0	22.6	18.0	18.2
1887.....	38.0	49.2	42.9	43.3	31.1	39.2	33.2	34.2	20.9	28.3	22.3	23.5
1888..... ..	39.3	46.5	41.4	42.2	32.0	41.1	33.5	35.0	25.5	31.7	27.4	28.0
1889.....	39.0	51.4	41.4	43.3	33.7	44.7	37.7	38.5	24.3	31.4	27.0	27.4
1890.....	40.0	53.2	44.3	45.4	31.7	40.2	32.5	34.7	7.6	16.8	11.3	11.8
1891.....	40.0	53.0	44.2	45.4	32.1	42.6	39.2	38.3	27.1	37.1	32.0	32.2
1892.....	40.2	53.1	44.0	45.3	35.3	41.1	35.8	36.8	16.8	26.9	21.0	21.4
Mean	40.9	52.9	44.3	45.7	30.4	39.1	33.2	34.5	20.1	26.5	21.2	21.7

TABLE 3a—*Monthly Temperature from 1893 to 1904.*

	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Mean.
1893 ..	12.5	17.2	27.0	37.8	53.7	64.0	66.7	65.8	53.0	49.4	34.6	13.8	41.3
1894 ..	12.4	16.0	32.5	41.9	52.3	62.1	67.2	61.1	59.2	46.4	29.8	21.4	41.9
1895 ..	.....	17.0	26.1	41.2	58.1	66.8	65.1	66.4	57.8	42.5	36.9	.....	.....
1896 ..	.....	24.1	24.3	42.7	53.3	62.4	66.0	64.0	55.5	44.7	34.6	19.5	.....
1897 ..	16.6	20.0	27.3	42.3	53.0	57.0	68.2	68.8	55.2	47.2	33.2	23.2	42.2
1898 ..	13.4	24.6	33.4	39.8	53.8	61.1	68.6	67.5	58.3	46.8	35.8	20.7	43.6
1899 ..	15.2	16.2	26.0	44.2	52.4	62.0	68.3	66.4	50.6	50.0	34.0	28.0	43.3
1900 ..	17.8	20.5	26.6	44.1	49.4	63.4	68.1	66.3	59.2	51.4	36.4	18.5	43.5
1901 ..	15.2	14.0	27.5	44.6	53.7	63.6	68.4	66.4	59.4	47.2	28.6	23.2	42.7
1902 ..	17.2	21.6	36.8	43.4	50.7	56.8	64.2	63.0	59.0	47.2	37.2	17.0	42.8
1903 ..	16.2	19.8	37.5	43.0	54.4	59.8	62.1	60.6	60.2	47.1	33.8	20.0	42.9
1904 ..	10.2	12.2	29.0	41.0	58.2	60.8	68.8	64.2	56.6	46.1	30.4	11.8	40.7
Av.	15.8	18.9	27.9	40.7	52.6	61.9	66.9	65.0	57.0	46.1	34.0	20.8	42.3

NOTE.—These averages refer to the entire period from 1869-1904 inclusive.

In Table 4, 1893-1904, the data for mean maximum and mean minimum do not appear for the years 1893-1896; the mean monthly temperature for these years is the mean of the tridaily readings, or ¼ (7+2+9+9). The monthly means for each hour have not been preserved. For 1897-1904 the mean monthly temperature is the mean of the mean maximum and the mean minimum. Records at 2 P. M. only were taken in this period.

TABLE 4.—*Monthly and absolute extremes and monthly mean temperatures.*

Year.	January.					February.				
	Absolute max.	Absolute min.	Mean max.	Mean min.	Mean monthly.	Absolute max.	Absolute min.	Mean max.	Mean min.	Mean monthly.
1893	51.2	−20.3	.....	.....	12.5	48.	−14.4	.....	.....	17.2
1894	45.6	−32.0	.....	.....	17.9	42.5	−29.5	.....	.....	12.9
1895	.....	.. ....	.....	.....	.....	41.	−10.1	.....	.....	17.5
1896	.....	.....	... ..	.....	.....	43.	−30.	.....	.....	24.1
1897	52.	−18.	28.0	5.0	17.4	43.	−16.	31.6	8.1	20.2
1898	40.	−30.	24.6	2.2	13.2	47.	−25.	33.9	15.4	24.3
1899	49.	−29.	26.8	3.7	16.0	52.	−16.	25.1	7.4	16.5
1900	46.	−19.	31.2	4.5	17.8	50.	−21.	31.6	9.4	20.5
1901	42.	−20.	23.7	6.8	15.0	40.	−18.	24.9	3.1	14.2
1902	47.	−16.	26.8	7.7	17.3	52.	−15.	31.7	11.4	22.1
1903	41.	−23.	24.6	6.9	15.7	50.	−16.	28.8	10.8	19.2
1904	41.	−26.	21.8	−1.1	10.3	43.	−26.	23.7	0.8	12.3
Mean	45.5	−23.3	26.0	4.9	15.3	45.9	−19.8	28.9	8.3	18.4

Year.	March.					April.				
1893	47.4	0.6	.....	.....	27.1	59.2	13.0	.....	.....	37.8
1894	63.3	8.2	.....	.....	32.0	77.4	12.3	.....	.....	42.0
1895	47.0	— 3.5	.....	.....	26.9	69.0	12.0	.....	.....	42.9
1896	43.0	— 7.0	.....	.....	24.3	.....	18.0	.....	.....	42.7
1897	48.	−11.	36.1	18.5	28.4	74.	14.	52.4	32.2	41.8
1898	60.	5.	45.3	21.5	32.2	65.	9.	48.6	30.6	38.8
1899	51.	— 3	34.3	17.6	26.5	84.	18.	56.7	31.8	43.3
1900	52.	−10.	39.1	14.0	26.6	78.	21.	56.2	32.0	44.1
1901	49.	−13.	36.7	18.3	27.7	76.	25.	53.5	35.6	44.7
1902	62.	2.	45.2	28.5	36.9	75.	27.	53.7	33.1	43.4
1903	64.	0.	47.4	27.7	37.5	76.	18.	55.7	30.9	43.0
1904	51.	— 7.	39.5	18.4	29.0	62.	16.	52.4	29.6	41.0
Mean	53.1	— 2.4	40.9	20.6	27.8	72.3	16.9	53.6	32.0	42.1

Year.	May.					June.				
1893	82.4	31.0	.....	.....	53.7	84.0	39.1	.....	.....	64.0
1894	84.9	30.0	.....	.....	52.4	88.0	37.0	.....	.....	60.9
1895	89.0	31.0	.....	.....	55.1	91.0	37.0	.....	.....	64.8
1896	.....	21.0	.....	.....	53.3	.....	.....	....	.....	.....
1897	76.	29.	62.0	43.0	52.1	83.	39.	67 5	46.4	57.0
1898	76.	28.	64.7	43.0	53.1	87.	36.	71.1	51.1	61.5
1899	80.	26.	64.6	40.1	52.3	87.	37.	73.9	50.0	62.1
1900	83.	26.	63.0	39.5	49.5	86.	38.	77.4	49.4	63.4
1901	85.	32.	64.5	42.9	53.9	91.	38.	74.9	52.2	63.8
1902	83.	28.	61.2	40.2	50.6	84.	34.	67.4	46.2	56.8
1903	83.	26.	69.4	39.5	54.4	81.	32.	73.3	47.4	60.4
1904	82.	29.	71.6	44.7	58.1	87.	38.	73.7	48.0	60.8
Mean	82.2	28.1	65.1	41.8	53.2	86.3	36.8	72.4	48.8	61.4

TABLE 4.—*Concluded.*

Year.	July.					August.				
	Absolute max.	Absolute min.	Mean max.	Mean min.	Mean monthly.	Absolute max.	Absolute min.	Mean max.	Mean min.	Mean monthly.
1893	89.5	46.1	.....	.....	66.7	95.0	46.7	.....	.....	65.8
1894	93.8	44.5	.....	.....	66.9	86.8	35.9	.....	.....	61.6
1895	89.0	43.0	.....	.....	64.5	86.0	41.0	.....	.....	64.1
1896	86.0	55.0	.....	.....	66.0	92.0	39.	75.0	54.0	64.7
1897	93.	43.	79.0	57.0	66.6	85.	41.	74.0	53.0	64.2
1898	99.	39.	79.5	57.6	68.3	85.	41.	78.3	56.7	67.3
1899	91.	41.	77.0	59.6	68.4	93.	40.	78.1	54.8	66.5
1900	89.	47.	79.8	56.4	68.1	.....	.....	.....	.....	66.3
1901	100.	40.	80.2	56.6	68.6	86.	43.	76.9	55.9	66.7
1902	87.	43.	75.3	53.0	64.7	85.	39.	74.4	51.8	63.1
1903	88.	34.	77.9	46.2	62.1	81.	38.	73.6	47.7	60.5
1904	87.	46.	80.4	57.2	68.8	88.	40.	76.6	51.8	64.6
Mean	91.9	43.5	78.4	55.5	66.6	87.3	40.4	75.9	53.2	64.6

Year.	September.					October.				
1893	71.8	30.7	.....	.....	52.3	72.0	25.5	.....	.....	47.9
1894	89.6	27.0	.....	.....	61.3	66.0	27.0	.....	.....	46.1
1895	92.5	26.5	.....	.....	56.6	73.9	13.0	.....	.....	42.9
1896	87.	28.	65.0	46.0	53.8	68.	23.	53.0	37.0	44.7
1897	90.	28.	68.0	42.0	56.2	79.	19.	60.0	34.0	46.9
1898	85.	29.	70.7	45.9	58.6	86.	19.	57.6	36.0	47.2
1899	88.	23.	67.9	45.3	56.6	76.	22.	62.2	37.7	50.0
1900	93.	27.	72.2	46.2	59.2	76.	19.	60.9	41.8	51.4
1901	89.	28.	71.1	47.7	59.5	71.	20.	58.0	36.4	47.6
1902	82.	30.	69.4	48.7	59.5	75.	17.	56.7	37.8	47.3
1903	89.	29.	74.0	46.5	60.2	71.	22.	57.8	36.4	47.1
1904	80.	26.	67.5	43.6	55 5	69.	20.	55.1	36.3	46.1
Mean	86.4	27.7	69.5	46.0	58.3	73.5	20.5	57.9	33.7	47.1

Year.	November.					December.				
1893	57.4	9.3	.....	.....	33.7	40.2	—22.0	.....	.....	14.3
1894	59.0	— 5.0	.....	.....	34.5	45.5	— 7.0	.....	.....	22.4
1895	71.0	10.0	.....	.....	36.9	.....	.....	.....	.....	.....
1896	68.	— 4.	32.8	25.9	34.6	45.	— 9.	29.0	10.0	20.0
1897	59.	3.	41.0	25.0	33.8	51.	—11.	30.4	15.9	23.3
1898	55.	10.	42.7	28.7	36.3	43.	—13.	29.6	11.8	21.4
1899	58.	8.	43.4	24.6	34.0	57.	— 9.	37.4	18.7	28.0
1900	72.	9.	42.6	28.6	35.6	45.	—16.	23.0	81.1	15.6
1901	58.	— 8.	37.3	20.0	28.6	55.	—17.	31.9	14.5	23.3
1902	58.	18.	46.0	28.3	37.2	53.	—28.	25.9	8.7	17.1
1903	70.	2.	43.7	23.9	33.8	50.	—10.	30.0	10.0	20.0
1904	50.	0.	39.7	21.1	30.5	39.	—27.	22.5	1.1	11.9
Mean	61.3	5.0	41.0	25.1	34.1	47.6	—14.7	28.8	11.0	19.7

Table 5 gives, in the second column, the average temperature for each month for the period of 24 years (1869 to 1892, inclusive), and in the third column the average temperature for 35 years (1869 to 1904 inclusive), also the highest and lowest mean temperature during the whole period (1869 to 1904):

TABLE 5.—*Mean and extreme monthly temperatures.*

Mouth.	Average for 24 years.	Average for 35 years.	Highest temperature.		Lowest temperature.	
			Degrees.	Year.	Degrees.	Year.
January	16.11	16.0	57.8	1890	—35.6	1878
February	19.33	19.2	52.0	1899	—30.6	1896
March	27.37	28.1	63.3	1894	—22.0	1869
April	40.56	40.0	84.0	1899	1.0	1874
May	52.17	52.4	90.0	1880	21.0	1896
June	62.18	61.8	98.5	1878	32.0	1903
July	67.16	67.1	100.0	1901	34.0	1903
August	65.09	64.9	96.7	1876	35.0	1873
September	57.12	57.3	93.0	1900	23.0	1899
October	45.61	46.1	86.0	1898	13.0	1895
November	35.22	34.2	72.0	1900	—16.2	1875
December	21.57	21.3	60.6	1888	—36.3	1890

VAPOR TENSION AND RELATIVE HUMIDITY.

In Tables 6 and 7 are given the vapor tension and the relative humidity at 7 a. m., 2 p. m., and 9 p. m., for 1869-1875, inclusive. From 1869-1875 the relative humidity was recorded at 7 a. m., 2 p. m., and 9 p. m., and the mean taken.

The hygrometer used throughout was of the Huddleston type and was made in Boston, Mass.

TABLE 6.—*Mean vapor pressure.*

Year.	January.			February.			March.			April.		
	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.
1869	.081	.099	.096	.078	.104	.100	.083	.112	.101	.172	.188	.177
1870	.101	.111	.112	.084	.104	.090	100	.107	.106	.190	.218	.209
1871	.074	.087	.090	.083	.096	.097	.150	.166	.161	.177	.190	.194
1872	.084	.002	.084	.066	.091	.088	.076	.092	.089	.152	.165	.169
1873	.079	.093	.087	.067	.082	.087	.106	.121	.127	.160	.164	.167
1874	.100	.123	.114	.078	.089	.090	.101	.117	.118	.126	.138	.134
1875	.044	.063	.062	.070	.089	.086	.091	.103	.108	.131	.141	.143

Year.	May.			June.			July.			August.		
1869	.262	.285	.289	.....	.....	.....	.474	.520	.491	.397	.405	.417
1870	.256	.267	.268	.467	.506	.465	.496	.497	.505	.470	.480	.459
1871	.239	.243	.238	.390	.411	.386	.487	.474	.485	.465	.476	.471
1872	.273	.288	.280	.445	.467	.463	.511	.522	.519	.517	.528	.545
1873	.242	.243	.250	.350	.343	.374	.505	.498	.487	.413	.418	.429
1874	.246	.262	.257	.374	.396	.402	.498	.528	.518	.436	.438	.466
1875	.249	.266	.257	.385	.445	.386	.500	.481	488	.528	.572	.562

Year.	September.			October.			November.			December.		
1869	.405	.424	.417	.265	.280	.263	.144	.170	.171	.....	.....	.....
1870	.345	.372	.373	.265	.275	.274	.172	.179	.167	.112	.116	.114
1871	.313	.334	.332	.262	.282	.271	.125	.136	.134	.084	.095	.092
1872	.385	.408	.415	.249	.259	.254	.158	.163	.169	.071	.085	.076
1873	.325	.358	.354	.247	.273	.271	.108	.109	.109	.086	.105	.105
1874	.384	.428	.398	.243	.260	.259	.153	.162	.159	.084	.104	.091
1875	.325	.375	.346	.239	.232	.226	.120	.133	.135	.086	.096	.096

TABLE 7.—*Relative humidity.*

Year.	January.			February.			March.			April.		
	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.	7 a. m.	2 p. m.	9 p. m.
1869.....	83	72	80	76	68	77	72	60	68	80	64	76
1870.....	87	70	84	88	70	81	77	53	66	84	58	78
1871.....	85	71	85	82	59	75	84	65	78	81	60	77
1872.....	90	68	87	90	61	77	87	63	78	75	50	72
1873.....	86	75	88	87	61	81	86	63	80	78	53	74
1874	89	79	89	87	64	80	75	56	71	74	57	71
1875.....	83	69	86	84	70	83	78	55	74	74	50	66

Year.	May.			June.			July.			August.		
1869.....	83	56	81	.....	.....	.....	84	60	83	83	54	80
1870.....	78	51	75	85	59	83	81	53	80	85	53	77
1871.....	74	48	67	82	57	78	88	55	81	88	54	80
1872.....	79	61	78	85	61	84	84	57	80	89	61	88
1873.....	69	45	72	77	50	77	80	54	80	83	53	80
1874.....	73	48	71	83	61	79	88	65	86	89	57	86
1875.....	75	53	68	79	59	79	86	56	84	92	62	89

Year.	September.			October			November.			December.		
1869.....	91	62	88	92	67	87	89	78	88	.....	.....	.....
1870.....	72	56	82	91	62	84	85	66	80	86	71	83
1871.....	89	47	81	87	60	81	86	66	82	87	75	89
1872.....	89	67	88	92	63	86	90	69	89	81	72	82
1873.....	85	60	84	89	61	83	83	64	79	87	68	86
1874.....	93	67	88	87	57	81	89	68	84	84	74	84
1875.....	89	61	85	88	65	81	88	70	85	88	67	85

PRECIPITATION.

In Table 8 are tabulated the precipitation records at Orono, Me., from 1869 to 1904, inclusive. They include the total precipitation, the total snowfall, the number of days with 0.01 inch or more precipitation, and the maximum in 24 hours, with the date on which maximum occurred.

Table 9 gives the days during the period in which the precipitation was 2.50 inches or over.

The rain gauge was a Huddleston pattern during the first half of the observations, but one furnished by the U. S. Weather Bureau during the last half. They were well located in an exposed place, about 100 feet from the nearest building.

The scarcity of heavy rainfalls between 1896 and 1904 is noticeable.

TABLE 8.—*Precipitation.*

Year.	January.					February.				
	Total inches.	Total snowfall, in inches.	Days with .01 inch or more.	Maximum in 24 hours.	Date of maximum.	Total inches.	Total snowfall, in inches.	Days with .01 inch or more	Maximum in 24 hours.	Date of maximum.
1869	2.54	10.75	14	0.80	5	4.26	32.25	11	1.38	7
1870	5.62	26.0	14	1.29	2	4.30	15.0	12	1.89	19
1871	2.60	13.5	13	1.50	17	2.53	14.0	7	.87	18
1872	2.18	16.0	8	0.76	17	1.70	13.5	7	.98	4
1873	4.09	22.0	18	0.63	5	2.96	28.0	8	1.15	22
1874	4.57	25.0	16	1.45	8	5.50	40.0	13	2.85	4
1875	2.00	19.7	11	0.47	22	3.80	8.5	11	.85	25
1876	3.92	23.0	17	1.35	20	8.39	25.5	14	4.45	15
1877	3.29	28.5	14	0.80	16	1.20	10.5	7	.60	13
1878	5.08	15.0	15	1.80	11	2.41	14.0	7	1.40	25
1879	3.28	31.5	12	1.24	3	3.56	16.0	13	1.88	12
1880	2.83	13.0	14	0.94	22	2.83	16.5	15	.74	24
1881	2.08	16.5	8	0.83	10	3.35	13.5	13	1.15	12
1882	4.19	30.0	19	0.80	22	3.96	30.0	12	1.20	5
1883	2.44	15.0	13	0.60	31	2.34	13.0	13	.64	5
1884	4.44	17.5	9	2.04	9	6.85	26.5	20	1.27	23
1885	4.73	31.0	11	1.40	28	4.45	22.0	8	2.20	10
1886	6.64	37.0	17	3.40	31	5.42	32.0	12	2.60	28
1887	7.56	33.5	17	1 98	24	5.89	33.5	11	1.41	24
1888	4.97	37.5	12	1.60	27	6.11	20.5	12	2.26	20
1889	5.37	15.5	11	1.35	8	5.20	28.3	14	2.12	7
1890	3.33	19.5	17	1.25	16	4.57	13.0	14	1.45	8
1891	7.66	32.5	17	1.67	12	2.95	14.0	16	.56	3
1892	4 80	18.5	13	1.57	13	1.96	17.5	12	.85	12
1893	0.85	.....	.....	.....	.....	5.75	.....	.....	.....	.....
1894	3.01	.....	2	2.0	30	1.73	15.0	2	.80	15
1895	.....	.....	.....	.....	.....	0.83	.....	.....	.....	.....
1896	.....	.....	.....	.....	.....	2.20	.....	.....	.....	.....
1897	3.08	23.3	7	1.0	28	2.38	9.5	5	1.38	7
1898	6.32	42.5	9	1.32	7	8.05	39.0	9	2.91	22
1899	2 75	10.0	5	1.25	6	2.27	13.5	7	.80	45
1900	8.14	26.3	10	1.98	12	6.75	23.0	10	1.94	13
1901	4.33	25.5	12	1.20	12	1.95	19.5	5	1.0	5
1902	3.65	13.0	10	1.73	22	1.80	18.0	8	.....	.....
1903	3.62	15.2	9	0.87	21	3.92	21.5	8	.74	12
1904	3.63	34 0	8	1.0	9	2.57	18.0	11	.62	22

TABLE 8.—*Continued.*

Year.	March.					April.				
	Total inches.	Total snowfall in inches.	Days with .01 inch or more.	Maximum in 24 hours.	Date of maximum.	Total inches.	Total snowfall, in inches.	Days with .01 inch or more.	Maximum in 24 hours.	Date of maximum.
1869	3.36	10.42	9	.953	23	2.39	1.75	11	1.98	1
1870	2.11	10.50	12	.813	29	3.55	2.0	12	1.37	21
1871	4.11	8.0	13	2.01	22	4.01	1.0	15	.92	29
1872	5.23	38.0	14	1.80	10	1.93	3.0	11	1.10	10
1873	4.70	31.0	14	.80	30	2.59	5.0	11	.785	19
1874	3.40	14.0	10	1.45	4	3.76	30.0	16	1.15	30
1875	4.45	33.6	16	1.58	25	3.85	4.5	10	2.44	5
1876	8.20	18.0	14	3.25	21	1.65	9.0	13	.64	6
1877	5.67	11.0	17	2.50	29	3.18	.5	12	1.10	6
1878	2.73	8.0	13	.72	18	3.46	0.0	20	1.05	7
1879	3.40	18.5	14	.86	31	3.51	0.0	16	1.04	30
1880	2.86	18.0	10	1.24	24	4.15	2.0	13	1.98	30
1881	3.64	5.5	11	1.53	12	1.28	6.0	7	.92	15
1882	5.20	15.0	19	2.85	2	2.05	9.0	14	.75	20
1883	1.89	7.5	7	.72	28	3.80	2.5	12	1.27	20
1884	4.37	22.5	16	1.35	27	3.38	0.5	18	1.52	16
1885	2.78	15.0	10	1.08	2	2.34	3.5	13	.83	5
1886	2.87	22.0	10	1.22	22	1.80	1.0	7	1.42	7
1887	5.88	26.5	15	2.90	29	5.08	14.0	10	3.26	30
1888	6.48	26.0	20	1.62	29	1.58	16.0	14	.50	21
1889	4.62	4.0	12	2.90	9	1.93	4.0	8	.92	27
1890	5.81	3.6	15	1.25	3	2.02	6.0	9	.81	5
1891	5.20	12.0	10	1.60	10	3.26	11.0	13	1.25	3
1892	2.52	17.0	7	1.00	3	1.12	0.5	7	.42	10
1893	1.45	.....	7	.82	12	2.18	.....	13	.65	15
1894	1.23	2.5	10	.39	25	1.18	3 5	7	.35	9
1895	2.39	1.6	.....	1.18	14	3.81	.....	11	1 42	9
1896	6.95	.....	.....	.....	.....	.....	.....	.....	.....	.....
1897	3.96	6.5	12	.72	10	3.03	0.0	10	.84	9
1898	2.23	13.0	7	.70	31	4.95	9.0	12	2.19	19
1899	4.76	28.0	11	.90	16	0.66	.5	2	.55	8
1900	5.47	16.5	5	2.20	16	2.01	0.0	7	.62	19
1901	5.46	11.8	11	1.80	21	5.12	0.0	9	1.86	23
1902	8.89	14.	19	1.86	17	2.94	0.0	13	.84	10
1903	6.22	2.	11	1.26	8	1.71	0.5	5	.62	8
1904	3.18	12.	9	.74	8	2.31	3.5	10	.64	10

TABLE 8.—*Continued.*

Year.	May.					June.				
	Total inches.	Total snowfall, in inches.	Days with .01 inch or more.	Maximum in 24 hours.	Date of maximum.	Total inches.	Total snowfall, in inches.	Days with .01 inch or more.	Maximum in 24 hours.	Date of maximum.
1869	2.95	0.0	14	1.20	4	.....	.....	.....	.....	.....
1870	1.96	0.0	11	.49	11	2.07	0.0	6	1.75	9
1871	3.48	1.5	12	2.12	5	2.58	0.0	12	.69	12
1872	3.92	0.0	15	.94	5	4.47	0.0	16	1.07	2
1873	1.96	0.0	11	1.32	12	1.32	0.0	12	.56	4
1874	4.74	0.0	8	2.60	31	4.93	0.0	14	1.80	18
1875	3.31	0.0	11	1.15	25	4.85	0.0	8	2.20	19
1876	3.73	0.0	14	1.15	29	2 56	0.0	11	1.42	5
1877	1.94	0.0	13	1.05	3	1.98	0.0	9	.74	8
1878	2.14	0.0	10	1.25	23	5.42	0.0	10	2.50	24
1879	1.80	0.0	13	.58	14	4.73	0.0	15	1.75	4
1880	2.17	0.0	12	1.30	31	.73	0.0	8	.28	8
1881	4.85	0.0	15	2.75	17	3.38	0.0	11	.94	29
1882	4.52	0.0	12	2.65	29	4.44	0.0	13	1.85	6
1883	5.10	0.0	17	2.98	24	3.66	0.0	10	1.04	21
1884	5.42	0.0	15	1.23	29	1.37	0.0	6	.80	24
1885	3.38	8.	8	1.15	2	4.60	0.0	10	2.60	30
1886	4.67	0.0	10	1.45	8	2.74	0.0	9	1.35	27
1887	1.25	0.0	8	.64	30	3.36	0.0	11	1.22	24
1888	2.81	0.0	10	1.44	14	3.65	0.0	10	1.26	23
1889	1.86	0.0	10	.78	10	4.93	0.0	16	.88	2
1890	10.52	0.0	19	2.35	6	3.84	0.0	15	.97	14
1891	2.81	0.0	12	1.55	17	3.20.	0.0	10	1.34	28
1892	1.94	0.0	11	1.13	23	5.96	0.0	17	2.10	20
1893	2.55	0.0	12	.67	17	2.69	0.0	12	.58	6
1894	3.84	0.0	7	1.40	19	2.90	0.0	9	.59	1
1895	2.13	0.0	5	.96	12	1.35	0.0	7	.45	27
1896	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1897	4.49	0.0	11	1.42	13	3.71	0.0	13	.94	4
1898	1.02	0.0	4	.61	30	5.28	0.0	10	2.10	.....
1899	4.12	0.0	9	1.27	20	4.10	0.0	13	1.17	14
1900	8.24	0.0	13	2.25	3	3.83	0.0	7	1.04	2
1901	2 07	Trace.	13	1.17	28	1.79	0.0	9	.50	23
1902	2.77	0.0	10	.74	26	6.03	0.0	16	1.25	26
1903	.73	0.0	3	.46	5	2.09	0.0	6	.77	13
1904	4.26	0.0	11	.96	11	2.17	0.0	8	.68	5

TABLE 8.—*Continued.*

Year.	July.					August.				
	Total inches.	Total snowfall, in inches.	Days with .01 inch or more.	Maximum in 24 hours.	Date of maximum.	Total inches.	Total snowfall, in inches.	Days with .01 inch or more.	Maximum in 24 hours.	Date of maximum.
1869	1.62	0	12	.53	16	1.91	0	8	.84	28
1870	1.78	0	12	.44	29	3.21	0	6	2.42	4
1871	2.13	0	16	.50	31	3.85	0	8	1.66	27
1872	2.68	0	16	.37	19	6.23	0	15	1.37	17
1873	3.26	0	12	.67	27	1.81	0	6	1.13	3
1874	2.10	0	9	.95	3	5.39	0	9	4.20	9
1875	2.11	0	12	.33	7	2.32	0	11	.16	4
1876	5.80	0	17	2.50	24	.91	0	4	.46	25
1877	1.64	0	10	.80	26	5.28	0	15	2.30	10
1878	4.77	0	8	1.30	22	3.00	0	12	1.40	18
1879	5.79	0	12	2.45	23	5.66	0	10	4.80	19
1880	3.32	0	12	.60	24	1.54	0	8	1.00	4
1881	2.72	0	18	1.04	27	5.89	0	12	2.95	8
1882	3.10	0	11	.65	2	1.64	0	6	.85	15
1883	6.90	0	15	2.95	14	.53	0	5	.40	23
1884	2.38	0	15	.65	6	3.17	0	11	1.00	22
1885	4.70	0	14	1.52	31	7.36	0	11	2.85	6
1886	1.05	0	8	.48	16	2.27	0	11	1.12	17
1887	7.11	0	11	4.38	25	4.60	0	10	1.92	11
1888	2.47	0	11	.80	11	4.59	0	19	1.34	14
1889	3.23	0	10	1.12	20	1.65	0	12	.35	9
1890	3.84	0	11	1.23	8	4.55	0	17	1.28	20
1891	3.56	0	11	1.27	24	4.67	0	10	2.04	27
1892	1.99	0	9	1.40	4	6.42	0	12	2.80	12
1893	3.23	0	9	.88	3	3.90	.....	.....	.....	.....
1894	2.41	0	6	1.16	24	2.01	0	6	1.28	3
1895	2.85	0	.....	.29	7	2.14	0	3	1.24	24
1896	2.58	0	.....	1.67	5	4.26	0	.....	.90	23
1897	2.02	0	9	.65	22	5.09	0	6	1.79	25
1898	2.44	0	5	.85	21	31.4	0	7	1.10	5
1899	4.49	0	10	2.00	21	.....	.....	.....	.....	.....
1900	2.53	0	9	1.34	25	1.58	0	9	.48	14
1901	2.75	0	11	1.15	30	3.76	0	8	2.06	25
1902	1.81	0	8	.40	8	4.96	0	10	2.45	11
1903	6.49	0	15	2.25	23	2.22	0	17	1.03	20
1904	2.43	0	10	.75	5	4.46	0	10	1.66	10

TABLE 8.—*Continued.*

Year.	September.					October.				
	Total inches.	Total snowfall, in inches.	Days with .01 inch or more.	Maximum in 24 hours.	Date of maximum.	Total inches.	Total snowfall, in inches.	Days with .01 inch or more.	Maximum in 24 hours.	Date of maximum.
1869	3.67	0	9	1.37	27	9.57	9	15	2.13	5
1870	2.23	0	6	1.12	4	5.53	1.5	12	1.82	20
1871	1.10	0	9	.38	27	7.50	0	12	4.43	12
1872	3.55	0	13	.92	24	6.01	0	13	1.25	2
1873	4.74	0	9	1.36	19	6.56	0	10	2.70	21
1874	4.37	0	10	2.90	20	1.14	0	7	.50	2
1875	5.10	0	10	1.95	17	4.75	0	15	1.31	31
1876	4.28	0	12	2.00	21	3.91	4	12	1.65	24
1877	1.11	0	5	.50	18	4.78	7	14	1.80	5
1878	2.00	0	9	.55	12	4.73	0	15	2.20	24
1879	4.93	0	10	2.25	8	3.49	0	10	2.30	29
1880	3.84	0	10	2.63	16	4.15	0	11	2.45	23
1881	2.35	0	9	1.00	11	3.57	0	14	1.98	18
1882	6.44	0	12	3.65	24	1.09	0	7	.53	18
1883	2.23	0	11	1.08	26	4.97	0	9	1.65	26
1884	2.19	0	13	.60	20	2.70	0	13	1.55	23
1885	2.52	0	5	1.56	23	5.12	0	12	1.56	3
1886	4.11	0	9	1.54	28	1.42	0	9	1.08	31
1887	.95	0	11	.54	25	3.00	0.25	9	1.15	21
1888	6.97	0	13	1.83	26	7.51	5	18	3.18	8
1889	2.21	0	5	1.28	19	4.04	0	11	1.89	30
1890	4.67	0	11	2.40	18	3.36	0	11	1.45	18
1891	3.68	0	8	2.37	7	2.85	0	11	1.70	8
1892	3.91	0	5	3.00	14	1.79	0	10	.65	27
1893	5.02	0	10	3.00	16	4.32	.....	.....	.....	.....
1894	3.40	0	5	1.70	20	1.53	.....	10	1.62	14
1895	1.05	0	3	.52	12	1.51	0.12	5	1.50	14
1896	8.00	0	9	4.34	6	3.75	0	15	.77	15
1897	2.65	0	7	.92	9	1.01	0	3	.88	12
1898	2.29	0	5	.94	5	6.19	0	7	1.71	5
1899	3.20	0	5	1.08	20	2.92	0	7	1.10	9
1900	2.94	0	7	1.22	21	5.70	T.	8	2.05	10
1901	4.22	0	8	1.39	11	4.12	T.	8	2.70	14
1902	1.94	0	8	.71	13	5.04	0	13	1.17	6
1903	1.21	0	4	.55	27	3.44	1.0	8	1.17	17
1904	6.47	0	13	2.37	14	3.10	T.	10	1.06	21

TABLE 8.—*Concluded.*

Year.	November.					December.				
	Total inches.	Total snowfall, in inches.	Days with .01 inch or more.	Maximum in 24 hours.	Date of maximum.	Total inches.	Total snowfall, in inches.	Days with .01 inch or more.	Maximum in 24 hours.	Date of maximum.
1869	3.36	.75	6	1.55	7	...	.....	....	....	.....
1870	5.61	5.50	15	1.38	4	3.04	18.25	13	.70	13
1871	3.58	15.0	13	2.10	8	4.16	27.50	16	1.20	23
1872	7.06	10.0	14	2.40	6	3.62	31.50	18	.50	22
1873	5.05	24.0	10	1.44	8	1.74	14.0	12	.46	13
1874	3.06	10.0	9	.95	23	1.98	13.0	9	.60	14
1875	3.87	14.2	10	1.45	11	1.51	13.0	13	.43	17
1876	4.35	0.5	10	2.50	8	4.67	43.0	12	1 40	18
1877	7.95	3.0	12	2.60	27	2.15	6.0	7	1.40	6
1878	4.91	8.5	15	1.75	23	7.92	14.0	12	3.53	10
1879	2.98	10.0	12	1.62	29	3.60	19.5	17	1.10	7
1880	3.52	7.0	13	1.53	7	1.90	12.5	14	.65	16
1881	2.81	5.0	11	1.40	4	6.88	8.0	15	1.98	23
1882	1.78	5	6	.70	13	2.85	21.0	14	.62	6
1883	3.75	3	11	1.22	27	2.99	12.0	16	1.22	28
1884	3.99	7	13	1.28	6	4.74	16.0	11	2.20	22
1885	5.37	0.5	14	2.68	9	5.64	28.0	15	2.24	20
1886	8.67	6	16	4.58	7	6.38	38.5	12	1.74	24
1887	3.48	1	13	1.80	16	4.72	6.5	14	2.12	12
1888	5.73	10	12	1.84	10	4.96	19.6	11	2.40	18
1889	4.50	6	11	1.41	3	3.40	6.5	11	.78	19
1890	2.67	4.5	8	1.05	18	4.10	28.5	15	1.10	27
1891	2.88	2	8	1.36	27	4.76	10.5	9	1.78	30
1892	4.47	4	13	1.22	19	2.26	6.5	7	.96	8
1893	1.43	.....	4	.53	22	4.21	.....	10	.80	5
1894	1.24	0.5	4	.37	10	1.75	.....	4	.90	27
1895	3.61	.....	....	1.25	8	....	.....	....	....	.....
1896	4.23	5.5	11	1.41	5	1.30	.....	6	.58	8
1897	5.04	6	8	1.10	3	3.58	12.8	10	1.22	5
1898	6.84	6	8	2.50	10	1.07	7.0	4	.37	5
1899	2.01	7.5	6	.86	15	3.09	6.5	9	.75	4
1900	4.59	7.8	1	1.89	26	2.02	11.8	6	.80	5
1901	2.54	19.8	9	1.50	12	7.94	21.5	12	1.89	15
1902	1.76	3	7	.81	12	4.74	24.3	11	1.13	16
1903	2.79	15.5	9	....	7	3.14	9.3	9	.96	13
1904	1.62	5.8	7	.83	14	2.00	19.2	7	1.10	28

TABLE 8a.—*Average Precipitation, 1869-1904.*

January	4.10	July	3.22
February	3.78	August	3.50
March	4.27	September	3.51
April	2.79	October	4.11
May	3.41	November	3.99
June	3.43	December	3.68

Average annual precipitation, 43.79.

TABLE 9.—*Days with 2.5 inches of precipitation.*

Year.	Day	Amount.	Year.	Day.	Amount.	Year.	Day.	Amount.
		Inches.			Inches.			Inches.
1871....	Oct. 12	4.43	1880...	Sept. 16	2.63	1887...	Apr. 30	3.26
1873....	Oct. 21	2.70	1881...	May 17	2.75	1887...	July 25	4.38
1874....	Feb. 4	2.85	1881...	Aug. 8	2.95	1888...	Oct. 8	3.18
1874....	May 31	2.60	1882...	Mar. 2	2.85	1889...	Mar. 9	2.90
1874....	Aug. 9	4.20	1882...	May 29	2.65	1892...	Aug. 12	2.80
1874....	Sept. 20	2.90	1882...	Sept. 24	3.63	1892...	Sept. 14	3.00
1876....	Feb. 15	4.45	1883...	May 24	2.98	1893...	Sept. 16	3.00
1876....	Mar. 21	3.25	1883...	July 14	2.95	*		
1876....	July 24	2.50	1885...	June 30	2.60	1896...	Mar. 4	4.60
1876....	Nov. 8	2.50	1885...	Aug. 6	2.85	1896...	Sept. 6	4.34
1877....	Mar. 29	2.50	1885...	Nov. 9	2.68	1898...	Feb. 22	2.91
1877....	Nov. 27	2.60	1886...	Jan. 31	3.40	1898...	Nov. 10	2.50
1878....	June 24	2.50	1886...	Feb. 28	2.60	1901...	Oct. 14	2.70
1878....	Dec. 10	3.53	1886...	Nov. 7	4.58			
1879...	Aug. 19	4.80	1887...	Mar. 29	2.90			

* Complete precipitation records were not kept during this period.

TABLE 10.—*Opening, closing of navigation, Penobscot River, Bangor, Me.*

Year.	Open.	Closed.	Year.	Open.	Closed.	Year.	Open.	Closed.
1816....	.....	Nov. 28	1847...	April 23	Dec. 21	1878...	April 2	Dec. 19
1817...	.....	Nov. 23	1848...	April 12	Dec. 21	1879...	April 24	Dec. 19
1818....	May 1	Dec. 10	1849...	April 1	Dec. 7	1880...	April 6	Nov. 26
1819....	April 19	Dec. 5	1850...	April 12	Dec. 8	1881...	Mar. 20	Dec. 11
1820....	April 18	Nov. 28	1851...	April 8	Dec. 30	1882...	April 10	Dec. 9
1821....	April 15	Dec. 1	1852...	April 21	Dec. 15	1883...	April 12	Dec. 16
1822....	April 10	Dec. 5	1853...	April 5	Dec. 8	1884...	April 6	Dec. 19
1823....	April 19	Dec. 9	1854...	April 27	Dec. 5	1885...	April 18	Dec. 17
1824...	April 1	Dec. 12	1855...	April 15	Dec. 1	1886...	April 16	Dec. 5
1825....	April 11	Dec. 14	1856...	April 16	Dec. 1	1887...	April 23	Dec. 22
1826....	April 5	Dec. 16	1857...	April 6	Dec 10	1888..	April 15	Dec. 13
1827....	April 2	Dec. 6	1858...	April 11	Dec. 12	1889..	Mar. 31	Dec. 14
1828....	April 1	Dec. 18	1859...	Mar. 30	Dec. 9	1890...	April 6	Dec. 6
1829....	April 14	Dec. 16	1860...	April 16	Dec. 7	1891...	Mar. 26	Dec. 16
1830....	April 9	Dec. 8	1861...	April 11	Dec. 20	1892...	April 2	Dec. 19
1831....	April 9	Dec. 3	1862...	April 18	Dec. 3	1893...	April 14	Dec. 13
1832....	April 19	Dec. 4	1863...	April 19	Dec. 2	1894...	Mar. 22	Dec. 23
1833....	April 9	Dec. 1	1864...	April 8	Dec. 12	1895...	April 5	Dec. 11
8834....	April 8	Dec. 9	1865...	Mar. 31	Dec. 8	1896...	April 12	Dec. 16
1835....	April 17	Nov. 27	1866...	April 1	Dec. 13	1897...	April 7	Dec. 22
1836....	April 12	Nov. 27	1867...	April 18	Dec. 4	1898...	Mar. 26	Dec. 14
1837....	April 15	Nov. 27	1868...	April 18	Dec. 10	1899...	April 10	Dec. 27
1838....	April 21	Dec. 24	1869...	April 11	Dec. 9	1900...	April 3	Dec. 12
1839....	April 17	Dec. 1	1870...	April 8	Dec. 21	1901...	April 2	Dec. 20
1840....	April 1	Dec. 1	1871...	Mar. 13	Nov. 17	1902...	Mar. 21	Dec. 8
1841....	April 17	Dec. 19	1872...	April 19	Dec. 10	1903...	Mar. 12	Dec. 18
1842....	Mar. 21	Nov. 19	1873...	April 19	Dec. 2	1904...	April 3	Dec. 6
1843....	April 21	Nov. 30	1874...	April 16	Dec. 11	1905...	Mar. 31	Dec. 12
1844...	April 12	Nov. 27	1875...	April 16	Nov. 29	1906...	April 6	Dec. 6
1845....	April 21	Dec. 7	1876...	April 12	Dec. 10	1907...	April 11	.....
1846....	Mar. 29	Dec. 15	1877...	Mar. 29	Dec. 30			

TABLE 11.—*Dates of some severe frosts at Orono, Me.*

Year.	Date.	Year.	Date.	Year.	Date.
1869	Oct. 6	1881	June 6, 7	1892	Sept. 8
1870	Sept. 12	1881	Sept. 21	1893	Sept. 11
1871	Sept. 11	1882	Sept. 13	1894	Sept. 3
1872	Oct. 5	1883	Aug. 29	1895	
1873	Aug. 28	1884	Sept. 13	1896	Sept. 5
1874	Oct. 4	1885	Sept. 12	1897	Sept. 27
1875	Sept. 11	1886	Sept. 14	1898	
1876	June 8	1887	Sept. 11	1899	
1876	Aug. 22	1888	Sept. 6	1900	
1877	Sept. 7	1889	Oct. 3	1901	
1878	Sept. 23	1890	July 19	1902	
1879	June 9	1890	Sept. 22	1903	Sept. 30
1879	Sept. 26	1891	Oct. 9	1904	Sept. 22
1880	Sept. 24				

TABLE 12.—*Thunderstorms at Orono, Me.*

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1869							2					
1870				2		2	1	2				
1871				1	1	2	3		1			
1872						2	2	2	3			
1873				1		1						
1874			1		1	2	2					
1875					2	1	2		1			
1876					1		1	1				
1877					1		2	4	1			
1878					3	2	5	1	1			
1879					4	2	3	1				
1880					4		5	1	1			
1881					1	2	3	4	1			
1882					2	3	6	2	2		1	
1883					1	2	2	2		1		
1884					2	3	3	1	1	1		
1885				2	2	2	3	1		3		
1886					2	3	3	1	2		2	
1887					1	2	5	3	2			
1888					1	3	2	3				
1889					1	4	4	3		1		
1890						2	2	2	1	1		
1891					2	3	1	4	2			
1892						2		5				
1893						2			1			
1894								1				
1895												
1896									1			
1897									1			
1898												1
1899							9					
1900				1	1							
1901	1		1				2	1				
1902				3	2		2	3				
1903									2	2		
1904				1	3	3	2		5			

TABLE 13.—*Solar halos at Orono, Me.*

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1869												
1870												
1871												
1872												
1873												
1874				1								
1875												
1876				1		1			1			
1877				1								
1878							1					
1879						1						
1880				1	1							
1881												
1882												
1883												
1884			1		1					1		
1885			1									
1886								1				1
1887	1			1								
1888			1		1							
1889		1										
1890		1		3	1			1				
1891		3			2							
1892				2	2							
1893			1	2							2	
1894		1		2								
Sum	1	6	4	14	8	9	1	2	1	1	2	1

TABLE 14.—*Lunar halos at Orono, Me.*

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1869				1								
1870			1									
1871												
1872		1			1							
1873												
1874	1			1								
1875				1					1			
1876			2									
1877	1		1									
1878		2								1		
1879	1								1	1		
1880			2	1				1				
1881	2	2		1						1		
1882		1										
1883						1						
1884	2				1				1	2		
1885			1	2								1
1886		1		1		1					1	1
1887		1	1	1						1	1	2
1888			1	1						1		1
1889	1	3	2		1							3
1890	4	1	2					1		2		
1891		1		1	1	2				1	1	1
1892	2	2	2		1							1
1893	1	7		3					1			
1894			2									
1895												
Sum	15	22	17	14	5	4	0	2	4	10	3	10

TABLE 15.—*Auroras at Orono, Me.*

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1869	.....	.....	4	5	2	.....	.....	.....	3	4	1	.....
1870	3	3	4	1	1	1	.....	1	2	1	2	2
1871	.....	5	3	2	2	2	2	1	5	2	8	2
1872	1	2	2	.....	2	.....	1	4	.....	3	3	2
1873	2	.....	1	3	1	3	2	.....	1	2	.....	.....
1874	2	1	.....	2	.....	.....	1	.....	2	5	.....	1
1875	.....	1	.....	2	.....	.....	.....	.....	1	.....	.....	.....
1876	.....	.....	.....	1	.....	.....	.....	.....	1	.....	.....	.....
1877	1	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....
1878	.....	1	.....	.....	.....	.....	.....	.....	1	.....	.....	2
1879	.....	.....	.....	1	.....	.....	.....	.....	1	1	.....	.....
1880	.....	.....	3	2	.....	.....	.....	4	.....	1	3	.....
1881	1	.....	.....	2	.....	.....	.....	.....	1	.....	.....	1
1882	.....	2	2	1	.....	.....	.....	1	.....	4	3	3
1883	.....	5	3	1	.....	.....	1	.....	1	1	.....	.....
1884	.....	.....	3	4	.....	.....	.....	.....	.....	1	1	.....
1885	.....	.....	.....	.....	1	.....	.....	3	1	1	1	3
1886	.....	.....	2	2	.....	1	.....	2	3	3	1	.....
1887	.....	2	.....	1	3	.....	.....	2	1	1	2	.....
1888	1	1	1	.....	3	1	.....	1	13	3	.....	1
1889	.....	.....	.....	1	.....	1	1	.....	.....	1	4	2
1890	3	2	.....	.....	.....	.....	3	2	3	2	5	.....
1891	1	1	3	1	3	1	.....	.....	4	2	3	1
1892	1	8	6	6	1	.....	4	1	3	5	1	3
1893	.....	.....	.....	1	.....	.....	.....	.....	2	.....	5	.....
1894	.....	5	2	.....	5	2	3	1	.....	.....	.....	.....
1895	.....	.....	.....	3	1	.....	.....	.....	.....	2	.....	.....
1896	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....	.....
1897	.....	1	5	3	.....	.....	.....	.....	.....	.....	.....	.....
1898	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	.....
1899	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1900	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1901	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1902	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1	.....
Sum	16	40	45	46	22	12	18	23	37	48	44	23

In Table 10 are given the dates of the opening and closing of navigation on the Penobscot River at Bangor each year from 1816 to 1905. Table 11 contains the dates of the severe frosts at Orono. Table 12 shows the number of thunderstorms each month from 1869 to 1904. Tables 13 and 14 give the solar and lunar halos, and in Table 15 are shown the number of auroras observed during each month. The following notes regarding various phenomena, while by no means complete, serve to indicate the character of the climate of Orono:

Ice.—The latest date on which ice was formed each year from 1869 to 1875 was, 1869, April 11; 1870, April 8; 1871, March 13; 1872, April 20; 1873, April 20; 1874, April 16; 1875, April 16.

Snow.—Five inches of snow fell on May 3, 1885.

Gales.—Gales or high winds are recorded on the following dates: 1875, October 31; 1880, February 1, March 30, April 29; 1883, November 12; 1884, November 23; 1886, November 6, 18.

Destructive winds are recorded on the following dates: 1870, July 14; 1873, July 26; 1882, August 15; 1890, July 8; 1892, June 14.

Parhelia are noted as follows: 1887, January 31; 1889, February 22; 1890, January 18, February 10, March 25, 31, April 29; 1891, February 2, 3, 5, 27, May 21, 22; 1892, February 7.

Meteors were seen: 1875, March 24; 1887, September 15; 1888, January 4, December 28; 1889, November 17; 1890, August 11, 12; 1891, January 8.

The zodiacal light was observed in the evening on the following dates: 1877, March 21; 1878, January 29, 30; 1879, January 10, 14, 23; 1880, January 11; 1882, March 7, 8; 1883, January 29, February 7, 8, 26, March 8; 1886, February 22, 23; 1887, February 14, 21; 1888, February 2, 3, 29, December 23; 1889, December 16; 1890, January 17, 18, 21, 29, February 9, 10, 11, 13, 15, 16, March 9; 1891, January 8, 10, February 2, 10, 27, March 6, 7. Observations were made practically every evening but of course certain of the phenomena may have been missed.

Earthquakes occurred: 1870, October 20; 1871, October 19; 1872, January 9; 1881, June 21.

Precipitation.—During the period in question the total annual rainfall averaged 36.00 inches and the snowfall 94.43 inches, making the average annual precipitation 45.44 inches, or 3.79 inches per month.

Cloudiness and wind.—The mean percentage of cloudiness for the twenty-four years was 52. The direction and force of the wind, recorded in accordance with the instructions of the United States Weather Bureau, resulted as follows: Northwest and west, 40 per cent; southwest and south, 28 per cent; northeast and north, 20 per cent; southeast and south, 12 per cent.

Barometric pressure.—The maximum barometric pressure reduced to 32° F. was 30.833 inches; the minimum, 28.423 inches; and the mean, 29.842 inches. The correction for gravity is inappreciable.

Humidity.—The mean pressure of vapor for fifteen years (1869-1884) was 0.257 inch of mercury.

The relative humidity ranged from a maximum of 100 per cent to a minimum of 10 per cent, with a mean for the 24-year period of 77 per cent.

Thunderstorms.—The number of thunderstorms observed during the period was as follows:

Year.	No.	Year.	No.
1870	7	1882	12
1871	5	1883	12
1872	10	1884	10
1873	4	1885	13
1874	4	1886	13
1875	6	1887	11
1876	4	1888	12
1877	7	1889	11
1878	9	1890	10
1879	12	1891	13
1880	9	1892	8
1881	13		

When these numbers are plotted there seem to exist periods of maxima and minima of thunderstorms.

Summary of temperature observations.

Mean of warmest day, August 7, 1876	85.3
Mean of coldest day, January 8, 1878	—17.2
Absolute highest temperature, August 31, 1876,	96.7
Absolute lowest temperature, December 31, 1890	—36.3
Mean of maximum temperatures	51.26
Mean of minimum temperatures	33.68
Mean of the mean maximum and minimum temperatures	42.47
Mean of three daily readings for the same period	42.48

The agreement between the last two numbers in the above list is remarkable. So far as these observations go, the average of the maxima and minima is essentially the same as the average of three daily readings when carried through a sufficiently prolonged period. Taking the records for each separate month of the twenty-four years, it is found that about once a year the mean from the maximum and minimum differs from that of three daily readings by as much as one degree.

A striking result is obtained if we take the mean of the mean daily temperature for each month of the period under consideration, and then in turn take the mean of the months which differ by six. This is shown, as follows:

Mean temperature for twenty-four years.

Month.	Mean.	Month.	Mean.	Mean of both.
	°		°	°
January	16.09	July	67.40	41.75
February	19.21	August	65.54	42.38
March	27.31	September	57.51	42.41
April	40.19	October	45 81	43.00
May	52.51	November	34.12	43.32
June	62.41	December	25.57	41.99
Average	36.29	Average	48.66	42.48

Comparing these results with the mean temperature for the whole period (42.48°), we observe that in no case does the mean of the pairs of months considered differ by as much as one degree therefrom. It is hoped that other observers who have recorded the data for long periods will apply this test.

The mean temperature for each month shows that the maximum occurred in July, 67.40°, and the minimum in January, 16.09°. This latter is contrary to the prevailing opinion regarding Maine temperature, as February is generally regarded as the coldest month. When the monthly means are plotted, the curve has the general characteristics of curves of this class plotted by other observers. See, for example, Loomis's Treatise on Meteorology, p. 31, where is plotted a like curve for New Haven, covering a period of eighty-six years. The similarity of the two curves is striking.

DAILY PRECIPITATION AND THE ACCUMULATION OF PRECIPITATION.

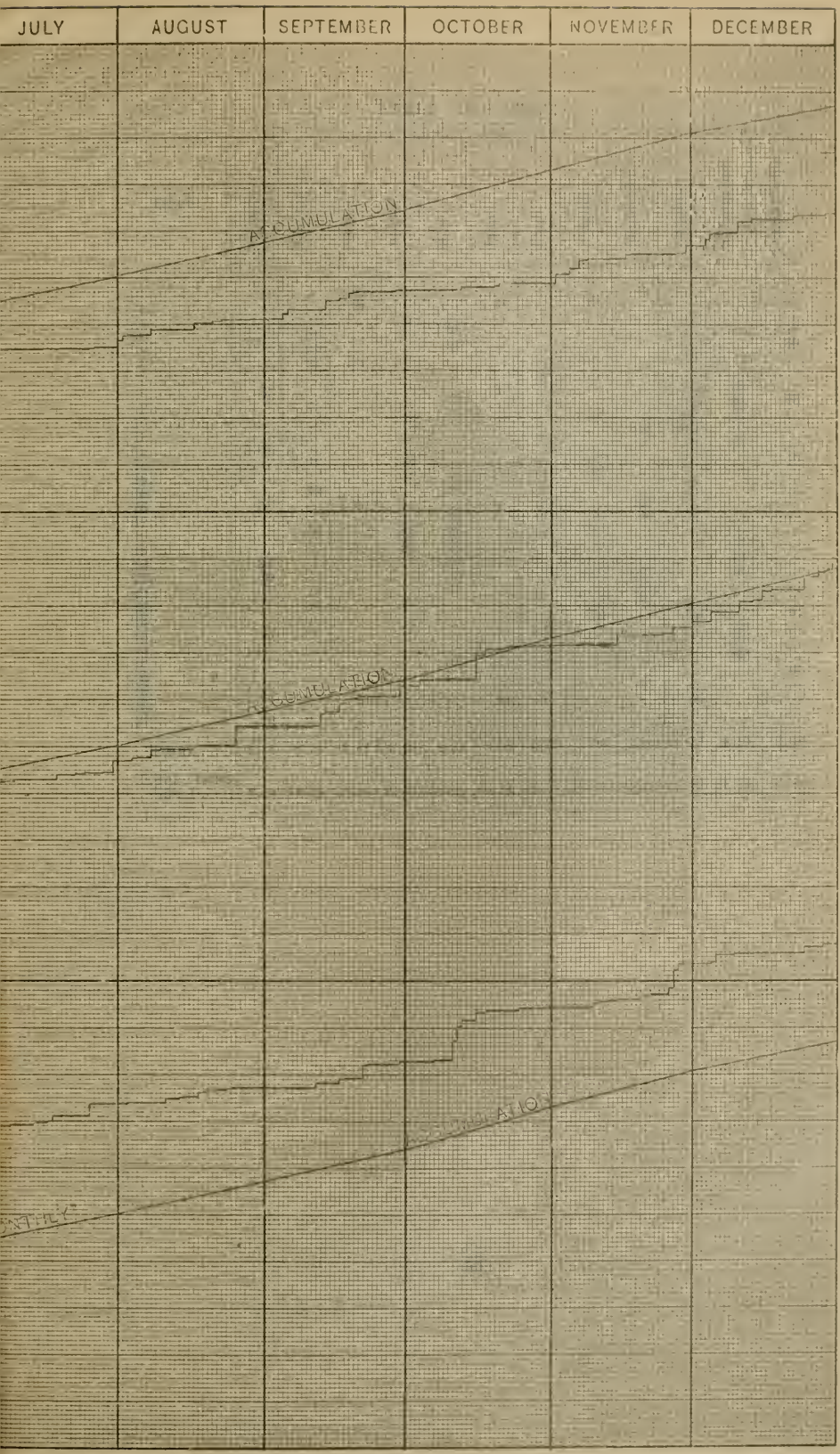
The following tables and curves show the amount of rainfall at Orono, Me., for each day from January 1, 1900, to January 1, 1907, and the total for each year from January 1 to the given time.

The accompanying curves show the mean monthly accumulation of rainfall for the years 1900, 1901, and 1905. The first of these years was characterized by an excess of precipitation, the second by a normal amount, and the third by an unusual scarcity.

The monthly mean accumulation curve was obtained by averaging the results obtained from the Experiment Station extending over a period of 35 years.

1800 1801 1802

1905
INCHES OF PRECIPITATION
0
5
10
15
20
25
30
35
40
45
JANUARY
FEBRUARY
MARCH
APRIL
MAY
MEAN
1901
INCHES OF PRECIPITATION
MEAN
1900
INCHES OF PRECIPITATION
MEAN


JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
ACCUMULATION
ACCUMULATION
ACCUMULATION

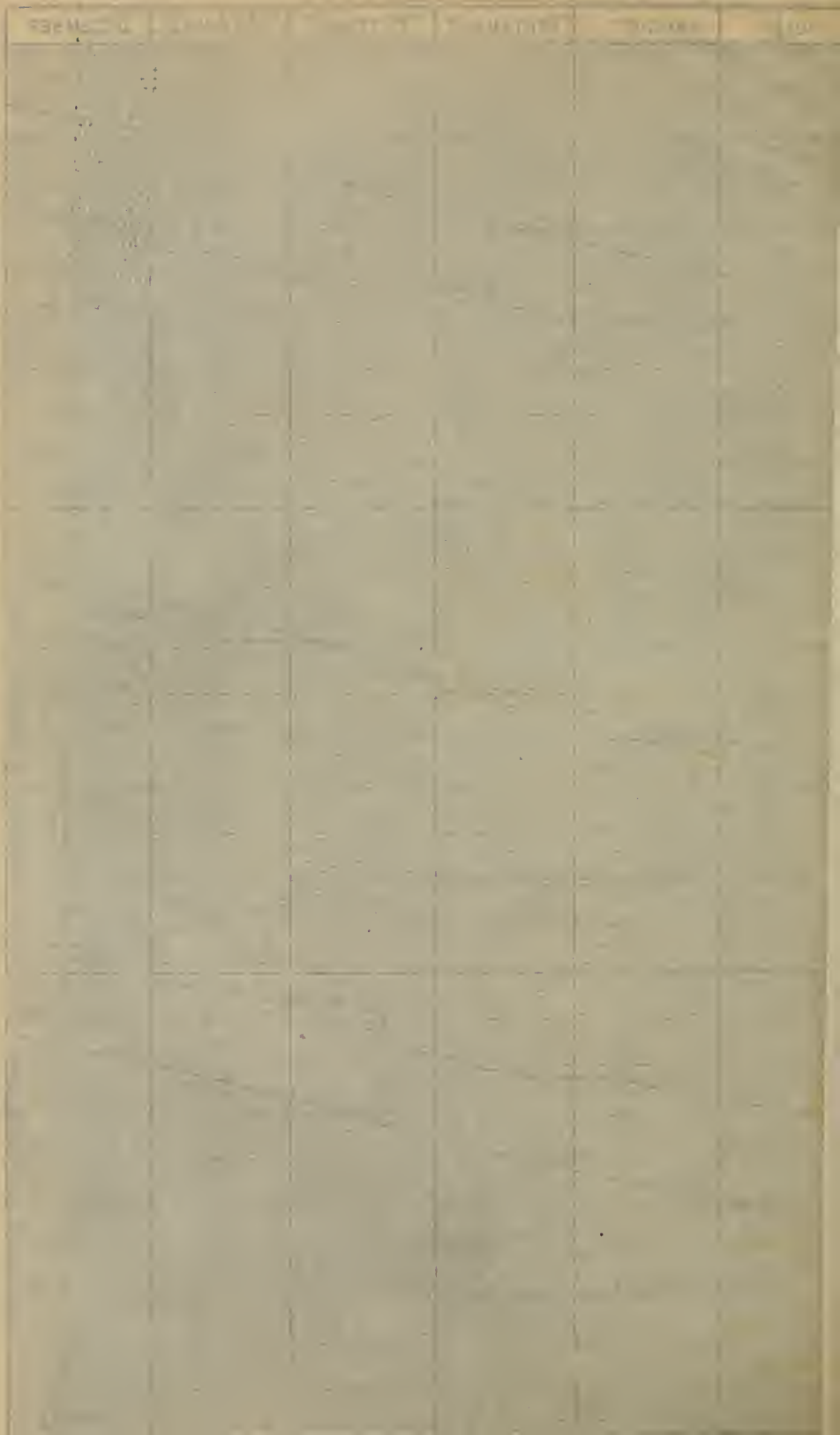


TABLE 16—1900.

Days.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	.80		1.54									
2			1.00			1.04		.04				
3				.58	2.25							
4		.50			.70							.13
5		1.43			.17							.80
6		.15	.61							.18		
7							.04					
8	.13					.17	.14				.06	
9		.13			.55						.47	.03
10				.03				.42		2.05	.21	
11									.64	1.49		
12	1.98						.20			.74	.03	
13		1.94		.12				.19				.15
14				.11	.46	1.03	.07	.02			.10	
15		.10			.49					.76		
16	.50		2.20				.16		.49			
17					.50		.54	.48	.04	.23		
18		1.00		.41	.62		.03	.17				
19			.12	.62	.76			.10			.37	
20	1.32				1.52						.04	
21	.30				.10		.01	.06	1.22		.20	
22		.25			.05				.13			
23		.05		.14				.06	.01			
24								.04		.20		.71
25	.90	1.20				.07	1.34				.60	
26	.27										1.89	
27					.07	.71					.62	
28												.20
29	1.44					.76			.41			
30						.05				.05		
31	.50											
Total	8.14	6.75	5.47	2.01	8 24	3.83	2.53	1.58	2.94	5.70	4.59	2.02
Total from Jan. 1	8.14	14.89	20.36	22.37	30.61	34.44	36.97	38.55	41.49	47.19	51.78	53.80

TABLE 17—1901.

Days.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	.05		.05	.05		.01			.01		.18	
2	.03				.11		.49					
3						.23		.34		.61		
4			.20					.01				1.20
5		1.00	.40	.80	.08		.05					
6		.30					.10			.06		
7	.10						.04	.84				
8				1.07		.39	.01	.03				
9			.15	.25		.09	.07	.08			.02	
10												1.06
11	.05		.82		.16							
12	1.20		.03	.12	.09	.04			1.30			
13					.05				.22			.10
14						.05					1.00	
15	.02	.65								2.70		1.07
16	.78							.40	.88			
17									.38	.60		.13
18	.15						.50					
19					.02	.50			.03	.04	.03	
20	.80								.35			
21			1.80			.43				.07		
22							.04			.06		
23				1.66	.02							
24	.50			.15	.10	.05	.09			.01	.06	1.39
25								2.06				
26											.75	
27	.45		1.21							.01		.40
28			.59		1.17		.21					
29			.15	.90	.23				1.05	.06		.41
30				.12	.02		1.15					1.18
31	.02		.06		.02						.50	
Total	4.33	1.95	5.46	5.12	2.07	1.79	2.75	3.76	4.22	4.22	2.54	6.94
Total from Jan. 1	4.33	6.28	11.74	16.86	18.93	20.72	23.47	27.23	31.45	35.67	38.21	45.15

TABLE 18—1902.

Days.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	.....	.....	.78	.02	.26	.34	.30	.....	.05	.05	.....	.....
2	.....	.....	.50	.06	.....	.....	.20	.01	.....	.....	.....	.....
3	.20	.50	.....	.....	.....	.30	.....	.....	.....	.....	.....	.20
4	.....	.....	.....	.....	.....	.13	.....	.....	.15	.....	.....	.....
5	.02	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
6	.....	.....	.....	.....	.....	.....	.....	.33	.....	1.17	.....	.60
7	.....	.....	.70	.....	.20	.....	.05	.18	.12	.14	.....	.20
8	.10	.....	.....	.....	.....	1 30	.40	.32	.....	.....	.08	.....
9	.....	.50	.....	.....	.09	.....	.....	.....	.....	.....	.....	.....
10	.....	.....	.40	.84	.....	.16	.34	.....	.60	.....	.....	15
11	.....	.....	.....	.39	.....	.....	.....	2.45	.....	.....	.....	.05
12	.70	.....	.....	.26	.....	44	.....	.....	.....	.....	.81	.....
13	.....	.20	.....	.20	.....	.26	.....	.....	.71	.05	.....	.....
14	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.12	.....
15	.15	.....	.....	.....	.....	.....	.31	.23	.....	.....	.....	.....
16	.....	.....	.....	.....	.....	.47	.04	.....	.....	.....	.....	1.13
17	.03	.....	1.56	.....	.....	.02	.17	.....	.....	.....	.....	.....
18	.....	.60	.....	.....	.....	.....	.....	.....	.....	.....	.....	.05
19	.05	.....	1.60	.....	.....	.....	.....	.....	.06	.35	.15	.....
20	.....	.....	1.03	.12	.....	.....	.....	.....	.....	.30	.....	.....
21	.....	.....	.72	.19	.....	.....	.....	.....	.....	.....	.....	.03
22	1.73	.....	.15	.10	.....	1.48	.....	.18	.....	.....	.03	1.09
23	.....	.....	.....	.08	.08	.....	.....	1.09	.05	.....	.....	.....
24	.....	.....	.04	.....	.45	.03	.....	.....	.....	.....	.....	.....
25	.....	.....	.....	.....	.....	.....	.....	.12	.....	.06	.....	.....
26	.05	.....	.....	.47	.74	1.05	.....	.05	.....	.....	.30	.....
27	.62	.....	.....	.02	.05	.....	.....	.....	.....	.21	.....	.90
28	.....	.....	.04	.....	.50	.....	.....	.....	.20	2.67	.27	.....
29	.....	.....	.81	.....	.06	.....	.....	.....	.....	.....	.....	.17
30	.....	.....	.56	.17	.31	.05	.....	.....	.....	.....	.....	.20
31	.....	.....	.20	.02	.03	.....	.....	.....	.....	.04	.....	.....
Total	3.65	1.80	8.89	2.94	2.77	6.03	1.81	4.96	1.94	5.04	1.76	4.77
Total from January 1.	3.65	5.45	14.34	17.28	20.05	26.08	27.89	32.85	34.79	39.83	41.59	46.36

TABLE 19—1903.

Days.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1												
2							.36			.05		
3	.54	.40										
4	.05	.41		.50							.30	.20
5		.60	.32		.46				.34	.63		
6	.40						.16					
7				.43			.73	.03			1.20	
8	.60		1.26	.62			.03					
9		.60				.34	.44	.26				
10							.11	.32				.62
11	.40		2.11			.51	.12					
12		.74								.90	.15	
13						.77						.96
14						.35						
15							.08			.04		
16		.08		.10			.05					
17	.07	.60	.16					.40	.30	1.17	.61	
18						.01			.02			
19					.25		.42					
20								1.03				
21	.87		.71		.02		.57					.66
22											.12	
23			.98				.08			.37		
24			.04								.18	.18
25				.06		.11	2.25	.03		.18		
26												
27			.10						.55	.10		.03
28	.07	.46									.03	
29							.52				.20	.50
30	.62					.03	.57					
31			.54					.15				
Total	3.62	3.89	6.22	1.71	.73	2.12	6.49	2.22	1.21	3.44	2.79	3.15
Total from January 1.	3.62	7.51	13.73	15.44	16.17	18.29	24.78	27.00	28.21	31.65	34.44	37.59

TABLE 20—1904.

Days.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1		.45	.10	.25			.02	.04		.02		
2							.18	.26	.17			
3	.50	.30	.48			.02	.50		.13		.05	
4									.60			
5						.58	.75		.06			.07
6						.43		.18				
7				.20		.02				.17	.02	.03
8		.20	.74			.01		.03	.03	.03		
9	1.00											
10				.64			.13					
11		.05					.11	1.66		.22		
12				.17	2.37							
13	.19						.31		2.37	.94		
14								.07		.10	.83	
15		.20	.20					.03				
16	.40			.25	.69						.03	
17								.65				
18			.30						.09	.02		.20
19		.20			.10							.10
20	.05		.12	.15	1.01				.31			
21					.01			1.47		1.06	.31	
22		.62			.03	.26		.07				
23	.49	.05	.69									.40
24	.10				.03		.07		.91	.06	.17	
25		.20	.05	.32		.46	.02					
26					.01	.13				.48		
27	.90				.01							
28		.30										1.10
29			.50				.34		1.24		.21	
30				.33		.26			.56			
31												.10
Total	3.63	2.57	3.18	2.31	4.26	2.17	2.43	4.46	6.47	3.10	1.62	2.00
Total from January 1.	3.63	6.20	9.38	11.69	15.95	18.12	20.55	25.01	31.48	34.58	36.20	38.20

TABLE 21—1905.

Days.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1								.44	.03		.84	
2	.08						1.24	.03				
3						.50						.85
4	.80				.47				.64		.71	.41
5									.39			
6		.40		1.36	.02	.57					.75	
7	1.85		.10		.09			.50			.05	.09
8			.05			.02		.12			.22	
9			.07		.61							
10	.05	.30		.02								1.20
11				.01								
12	.35									.23		
13		.50			.03	.69			.98	.01	.06	.30
14												
15				.06			.03					
16				.04	.68			.60	.15		.41	
17	.05	.35			.80						.10	
18					.19				.69			
19	.30		.23		.17		.02		.05	.31		
20					.06			.27	.03	.23		
21				.73								.11
22	.50					.81		.17				.22
23												.04
24									.07			
25		.25					.07					
26	.30	.40	.36		.02		.10					
27			.02			.51					.15	
28						.03			.12			
29											.79	.29
30					33				.04			
31							.73					
Total...	4.28	2.20	.83	2.22	3.47	3.13	2.19	2.13	3.19	.78	4.08	3.51
Total from January 1.	4.28	6.48	7.31	9.53	13.00	16.13	18.32	20.45	23.64	24.42	28.50	32.01

TABLE 22—1906.

Days.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	.....	.....	.....	.....	.15	.10	.....	.....	.....	.....	.09	.05
2	.....	.....	.....	.....	.....	.24	.....	.....	.....	.....	.63	.....
3	.....	.....	.30	.....	.33	.02	.....	.....	.66	.....	.....	.10
4	.47	.....	1.42	.....	.....	.....	.....	.....	.....	.....	.....	.....
5	.....	.05	.....	.....	.20	.....	.51	.....	.....	.....	.....	.....
6	.....	.....	.....	.19	.08	.88	.....	.02	.....	.93	.....	.45
7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.07
8	.....	.....	.....	.....	.....	.....	.....	.....	.03	.....	.07	.....
9	.....	.88	.....	.....	.....	.05	.08	.....	.07	.....	.....	.....
10	.....	.....	.76	.....	.89	.27	.....	.....	.01	2.02	.08	.....
11	.....	.....	.....	.90	.01	.....	.50	1.24	.....	.19	.19	.60
12	.41	.....	.....	.....	.....	.....	.01	.01	.....	.....	.36	.....
13	.....	.....	.....	.....	.09	.....	.....	.....	.....	.....	.13	.....
14	.....	.....	.....	.....	.....	.....	.....	.01	.04	.....	.03	.....
15	.....	.80	.50	.....	.15	.....	.....	.....	.....	.....	.15	.20
16	1.41	.....	.....	.95	.14	.....	.....	.....	.....	.....	.48	.15
17	.....	.....	.02	.....	.08	.....	.10	.....	.....	.....	.....	.....
18	.20	.....	.....	.....	.....	.....	.....	.....	.11	.....	.....	.....
19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
20	.10	.....	.60	.04	.....	.....	.10	.....	.....	.21	.....	.05
21	.....	.09	.....	.....	.....	.....	.24	.....	.....	.....	.....	.59
22	.....	.....	.15	.02	.....	.39	.....	.....	.....	.....	.11	.01
23	.....	.....	.....	.....	.....	.....	.20	.....	.03	.10	.....	.20
24	.50	.....	.....	1.29	.....	.87	.....	.35	.....	.....	.....	.....
25	.....	.....	.....	.07	.48	.....	.....	.....	.....	.91	.....	.....
26	.....	.45	.....	.01	.04	.....	.....	.....	.....	.....	.....	.90
27	.....	.....	.....	.03	1.13	.01	.02	.06	.41	.....	.34	.....
28	.....	.....	.28	.....	.85	.....	.....	.....	.....	.48	.....	.....
29	.....	.....	.....	.....	.82	.03	.71	.....	.....	.....	.05	.....
30	.....	.....	.....	.15	.....	.....	.....	.....	.15	.01	.....	.....
31	.....	.....	.31	.....	.....	.....	.....	.....	.....	.05	.....	.....
Total	3.09	2.27	4.34	3.65	5.44	2.86	2.47	1.69	1.51	4.90	3.52	3.37
Total from January 1.	3.09	5.36	9.70	13.35	18.79	21.65	24.12	25.81	27.32	32.22	35.74	39.11

The principal object of these experiments was to compare the relative rates of evaporation of certain liquids under different conditions of temperature, surface, wind velocity, etc. Two Babington's atmidometers (A and B) were employed.

The scale divisions on each instrument were carefully calibrated, and the following constants determined:

A, 15.4 grams per division; B, 25.3 grams per division.

That is to say, it required these masses to be placed in the upper pan to depress each stem through one scale division. It is obvious therefore that the total evaporation in the pan of A which would cause a rise of one division, would be equivalent to 15.4 grams.

The pans used had slightly different diameters, so that the surface areas exposed were as follows: A, 7.1 sq cm., B, 6.2 sq. cm.

The observations were made by filling the pans with the liquid to be tested, then focusing the cross wire of a telescope on a certain division on the scale, and noting the rise due to evaporation in given intervals. That the evaporation rates were fairly constant is shown by the figures in Table 1 which give an idea of the nature and results of the experiments with ether and alcohol. The time interval was five minutes, and there are recorded the corresponding scale readings, the rise due to evaporation and the equivalent in grams for each liquid. Both these sets of observations were made simultaneously. When the surface of B is reduced to the same dimensions as that of A it is seen that ether evaporates nearly ten times as rapidly as alcohol.

In Table 24 the conclusions of a series of observations similar to those in Table 23 are given. The temperature, pressure, and relative humidity were kept fairly constant. Expressing these results relatively, water being taken as unity, we have the following: Water, 1.0; alcohol, 3.2; carbon bisulphide, 8.8; ether, 28.8; chloroform, 40.0.

In Table 25 a comparison is made of the relation of evaporation to the extent of surface. If we multiply the evaporation of A by the surface of B it should equal the evaporation of B multiplied by the surface of A. Our result gives 0.248 and 0.247,

respectively, which shows that within the limits of the accuracy of the experiment evaporation is proportional to the extent of the surface.

TABLE 23.—*Ether and alcohol.*

Periods.	Ether, A.			Alcohol, B.		
	Readings.	Differences.	Grams.	Readings.	Differences.	Grams.
h.m.						
1.51	2.8			6.6		
56	9.2	6.4	0.41	7.5	0.9	0.03
2.01	15.3	6.1	0.39	8.5	1.0	0.03
06	20.9	5.6	0 36	9.4	0.9	0.03
11	26.9	6.0	0.38	10.4	1.0	0.03
16	32.7	5.8	0.37	11.6	1.2	0.04
21	37.8	5 1	0.32	12.5	0.9	0.03
26	42.9	5.1	0.32	13.6	1.1	0.04
31	48.4	5.5	0.36	14.8	1.2	0.04
36	54.8	5.4	0.35	15.7	0.9	0.03
41	60.5	5.7	0.37	16.7	1.0	0.03

Mean, A, 0.36. Mean, B, 0.033. B reduced to surface area of A = 0.038.
Temperature, 23.0° C. Pressure, 758.9 mm. Relative humidity, 42 per cent.

TABLE 24.—*Conclusions from experiments with various liquids.*

Liquids.	Periods.	Evaporation ratios.	Temperature.	Pressure.	Relative humidity.
	Minutes.		°C.	Mm.	%
Water and alcohol	10	0.024 :0.08	24.7	748.5	41
Chloroform and carbon bisulphide	1	0.10 :0.022	23.3	753.8	50

TABLE 25.—*Comparison of surface areas. Chloroform.*

Periods.	Readings.	Differences.	Grams, A.	Readings.	Differences.	Grams, B.
h. m.						
9.58	3.0			1.0		
59	4.5	1.5	0.05	1.5	0.5	0.032
10.00	5.5	1.0	0.03	2.0	0.5	0.032
01	6.8	1.3	0.05	2.4	0.4	0.026
02	7.8	1.0	0.03	3.1	0.7	0.045
03	8.9	1.1	0.04	3.8	0.7	0.045
04	9.9	1.0	0.03	4.4	0.6	0.039
05	11.0	1.1	0.04	4.9	0.5	0.032
06	12.0	1.0	0.03	5.4	0.5	0.032
07	13.3	1.3	0.05	5.8	0.4	0.026
08	14.8	1.5	0.05	6.4	0.6	0.039

Mean, A, 0.040. Mean, B, 0.0348. Ratio of surfaces, 7.1 : 6.2.
Temperature, 16.6°, C. Pressure, 763.9. Relative humidity, 45 per cent.

Table 26 indicates that the *relative* evaporation of liquids is approximately constant, and is independent of the velocity of the wind over the exposed surface. In the above work the temperature was different under the two conditions by an average of about 12° C. It was determined that in the case of ether a difference of 1° C. corresponded to a difference of about 0.001 gram per minute.

TABLE 26.—*Rate of evaporation with and without wind.*

Liquids.	Evaporation per minute (no wind).	Velocity of wind, feet per minute.	Corresponding evaporation.
Alcohol	0.007	188	0.03
Chloroform	0.04	200	0.16
Ether	0.072	220	0.28

THE EVAPORATION OF SNOW AND ICE.

The object of the series of experiments on the evaporation of clear ice and snow is to determine to what degree the evaporation is affected by (a) temperature, (b) amount of atmospheric pressure, (c) velocity of wind, and (d) area of exposed surface.

It has been assumed that the laws for the evaporation of solids like ice follow those for liquids. Dalton states that: "Evaporation is that process by which liquids and *solids* assume the gaseous state at their free surfaces. The *rate* of evaporation depends upon temperature of the liquid or *solid*, the extent of the exposed surface, and the facility with which the gaseous particles can escape from the neighborhood of the surface either by diffusion through the air or by the motion of the air itself." This is equivalent to saying that evaporation of liquids and solids depends upon temperature, amount of exposed surface, atmospheric pressure, humidity, and wind.

The evaporation of a liquid may be seen at any time and that of a solid such as ice is often seen in the winter and spring when snow disappears with the temperature continually below 0° C. Also some chemical substances such as camphor and iodine evaporate without first passing into the liquid state.

Two different methods were used in this experiment, which continued throughout the first three weeks of the month of March, 1906, whenever the temperature remained below 0° C. During the first two weeks of the month the conditions were quite favorable. Attempts were made previous to March; but the weather was so mild for a greater part of the winter months —Dec., Jan., and Feb.—that nothing was accomplished from which any conclusions could be drawn.

FIRST METHOD.

A piece of clear ice, in a cubical form, measuring 5 cm. on a side, was weighed in a small wire holder so arranged that the ice was exposed to the air freely on all sides. After each weighing the ice with holder was taken from the balances and suspended in the free atmosphere. The temperature was carefully taken, estimating to tenths of a degree, and the barometric pressure estimating to hundredths of an inch. These readings on weight, temperature, and pressure were taken and recorded every hour during the day from 9 a. m. to 4 p. m. for seven successive days. This experiment was performed in the attic of the Camden High School building.

A maximum and minimum thermometer hung near the piece of ice and from this the temperatures were taken for each night excepting the first—February 28.

The average evaporation per hour was found each night excepting March 2. It was found that this hourly evaporation during the nights was considerably less than during the days.

TABLE 27.—*Data obtained by weighing method.*

Average loss per hr. .13 g. Loss in volume = 10.93 cm.³

Date 1906.	Hour.	Temperature C.	Pressure in in.	Weight of ice.	Loss in weight per hour.	Remarks.
Feb. 28..	9	−8.0	29.5	115.360		
	10	−8.	29.5	115.224	.136	
	11	−8.1	29.5	115.089	.135	
	12	−8.0	29.52	114.954	.135	
	1	−7.8	29.51	114.816	.138	Cloudy.
	2	−7.3	29.5	114.676	.140	Hourly evap. .139 g.
	3	−7.1	29.5	114.533	.143	
	4	−6.9	29.49	114.386	.147	
Mar. 1..	9	−7.3	29.7	112.511	.125	Min. temp. −11° C.
	10	−7.1	29.7	112.362	.149	
	11	−6.9	29.71	112.206	.156	Partly cloudy.
	12	−6.6	29.705	112.048	.158	
	1	−6.	29.71	111.888	.160	Hourly evap. .145.
	2	−5.2	29.7	111.723	.165	
	3	−4.9	29.72	111.559	.164	
	4	−5.1	29.72	111.395	.164	
Mar. 2..	9	−8.1	30.05	109.430	.130	Min. temp. −10° C.
	10	−8.	30.09	109.292	.138	
	11	−7.6	30.1	109.150	.142	Fair.
	12	−7.1	30.	109.003	.147	
	1	−6.5	30.02	108.838	.165	Error due to hasty reading.
	2	−6.2	30.	108.695	.143	
	3	−5.7	29.95	108.535	.158	
	4	−5.5	29.93	108.375	.163	
	5	−6.	29.93	108.203	.169	Hourly evap. .154.
Mar. 3..	8	−5.	29.2		.138	Min. temp. −6.5° C.
	9	−3.7	29.		.170	
	11	−1.	29.		.178	Dim. of ice at time of last reading 4.85 cm. Volume therefore 114.07 cm.³
	12	−0.	No reading taken			

Surface area 150 cm.² Volume 125 cm.³

On March 3rd at 12 o'clock the temperature became 0° C. and as the ice began to melt no further readings were taken.

The dimensions of the cubical piece of ice used decreased in the 74 hours from 5 cm. to 4.85 cm. or the volume from 125 cm.³ to 114.07 cm.³, while the weight decreased from 115.36 g. to 103.807 g. or a loss of 11.353 g. in 74 hours making an average hourly decrease by evaporation of 0.153 g.—approximately.

From these data it may be seen that the amount of evaporation increases as the temperature increases when the pressure remains constant, and as the experiment was performed indoors there was no wind or air currents. The glass sliding door of

the balance was kept open while all weighings were being made to avoid the effect of heat on the experiment. During each of these days the pressure was quite constant. Feb. 28th it held about 29.5, March 1st approximately 29.7, while on March 2nd it was 30, and during the time that the temperature was below 0° C. for the 3rd the pressure was 29.9 so we may consider each of these days as having a fairly constant barometric pressure, and consequently determine the effect of temperature change during each day.

During the first day the temperature increased from -8° C. to -6°.9 C. while the amount of evaporation increased from 0.136 g. to 0.147 g. per hour. The second day the temperature increased from -7°.3C to -5°.1C., the evaporation per hour from 0.149 g. to 0.164 g. The third day the temperature increased from -8°.1C. to -6°C., the evaporation from 0.138 g. to 0.169 g. per hour.

It may be seen also that the amount of evaporation increases as the atmospheric pressure increases. This is due, without doubt, to the fact that the humidity of the air is less with a larger pressure than with a low pressure, and it seems that the evaporation is less on cloudy days than on partly cloudy, and less when partly cloudy than when fair. At 2 p. m. the first day is noticed a temperature of -7°.3 C., at the end of the hour, 7°.1 C., while the amount of evaporation for the hour is 0.143 g. On the second day at 9 and 10 a. m. we find the same temperature but an amount of evaporation of 0.149 g. or an increase of 0.006 g. per hour. On the first day from 9 to 10 a. m. we find an evaporation of 0.136 g., while on the third day for the same hour we have 0.138 g. evaporation. As all other conditions apparently remain the same the conclusion is that the evaporation increases with atmospheric pressure, or with a decrease of humidity.

The minimum temperature for each night was recorded by the maximum and minimum thermometer. It was found that the amount of evaporation per hour during the night is considerably less than during the day—the average for the three nights being 0.131 g. per hour while the average for an hour in the day is 0.153 g.

Next a piece of ice in the cubical form, as nearly as could be cut and shaved, with a side of 3.54 cm. or 44.356 cm.^{3} in volume was used and the following data obtained, the method of procedure being the same as in the previous case. It will be noticed that the amount of exposed surface in this case is approximately one-half as much as in the previous part of the work.

TABLE 28.—*Data obtained by weighing method.*

Surface area 75.18 cm^2. Volume 44.36 cm^3. Weight 40.81 g.

Date 1906.	Hour.	Temperature C.	Pressure in in.	Weight of ice.	Loss in weight per hour.	Remarks.
Mar. 4...	9	—10.5	30.30	40.810		
	10	—10.1	30.30	40.746	.064	
	11	— 9.6	30.32	40.671	.065	
	12	— 8.5	30.31	40.606	.065	
	1	— 8.	30.30	40.539	.067	Fair.
	2	— 7.3	30.28	40.473	.066	
	3	— 5.1	50.29	40.406	.067	
	4	— 5.2	30.30	40.341	.065	
	5	— 5.4	30.30	40.273	.068	
Mar. 5...	9	— 8.9	30.28	39.313	.....	Min. temp.—12.
	10	— 8.2	30.26	39.251	.062	
	11	— 7.3	30.25	39.186	.065	
	12	— 6.1	30.25	39.116	.070	
	1	— 5.	30.25	39.054	.062	
	2	— 4.9	30.26	38.994	.060	Fair.
	3	— 5.2	30.27	38.931	.063	
	4	— 6.	30.27	38.863	.068	
	5	— 7.8	30.27	38.799	064	
Mar. 6...	9	— 6.	30.10	37.823	.....	Min. temp.—10.5.
	10	— 5.4	30.11	37.757	.066	
	11	— 4.3	30.08	37.690	.067	Cloudy in A. M. fair in P. M. with heavy wind.
	12	— 3.6	30.08	37.620	.070	
	1	— 3.4	30.07	37.555	.065	
	2	— 2.2	30.09	37.487	.068	
	3	— 2.	30.09	37.418	.069	
	4	— 1.5	30.09	37.346	.072	
	5	— 1.5	30.08	37.241	.075	

Average per hour .0637.

The data were obtained by the same method, same apparatus, and in the same place as the data in Table 23.

The average evaporation was 0.0637 g. per hour. The area of the exposed surface was approximately one-half of that in the first part being 75.18 cm.^{3} while in the first it was 125 cm.^{3} The amount of evaporation is approximately one-half,

thus proving that the amount of evaporation is proportional to the area of the exposed surface.

The second table shows, as the first did, that the amount of evaporation increases as the temperature increases.

SECOND METHOD.

In this method the ice was placed in a wire cage suspended from a coiled spring. By use of an index and scale the rise of the ice due to evaporation could be accurately measured. A box 3 x 1 x ½ was placed outside the laboratory window, and in this box was placed the barometer, thermometer, and wire suspended from the top. The velocity of the wind was estimated according to directions given in Ward's Laboratory Exercises in Meteorology.

By this method it was possible to make all readings through the window and thereby allow no heat to reach the snow or ice from the laboratory. The window was on the north side of the building where the sun did not strike the box during the day. As only the side of the box facing the window was taken out it was not possible for the wind to strike the apparatus with much force; but a free circulation of air was obtained.

TABLE 20.—*Data obtained by wire method.*

Date. 1906.	Hour.	Temperature C.	Pressure.	Height of ice.	Loss in weight per hour.	Remarks.
Mar. 12..	12	—3.	30.00	30.5		Nimbus clouds.
	1	—3.	30.00	30.67	.17 cm.	
	2	—3.	30.00	30.84	.17	Snow P. M.
	3	—4.1	30.00	31.00	.16	Average evap. per hr. .158 cm.
	4	—5.	30.05	31.15	.15	
	5	—6.	30.05	31.29	.14	Wind W. Vel. 1.
Mar. 13..	8	—6.3	30.30	35.44		New piece of ice.
	9	—6.	30.29	35.61	.170	
	10	—5.4	30.30	35.80	.190	No clouds.
	11	—4.8	30.31	36.00	.200	Wind W. Vel 4.
	12	—3.6	30.31	36.227	.227	
	1	—2.4	30.31	36.465	.238	
	2	—1.5	30.32	36.700	.245	Average evap. per hr., .22.
	3	—1.	30.33	36.950	.240	
	4	—0.5	30.30	37.200	.250	
Mar. 14..	9	—3.	29.89	34.786	.142	Same piece of ice.
	10	—2.	29.93	34.618	.168	
	11	—2.	29.93	34.447	.171	No clouds.
	12	—1.5	29.90	34.269	.178	Wind N. W. Vel. 2.
	1	—1.0	29.99	34.089	.180	
	2	—1.5	29.99	33.911	.178	Average evap. per hr., .16.
	3	—3.	29.99	33.839	.172	
	4	—3.2	30.00	33.669	.170	
	5	—4.	30.00	33.503	.166	

From these data it is seen that the amount of evaporation increases as the temperature increases. On March 12th the temperature decreased from -3° C. to -6° C. and the amount of hourly evaporation decreased from 0.17 cm. to 0.14 cm. On the 13th the temperature increased from -6°.3 C. to -0°.5 C. and the evaporation increased from 0.17 cm. to 0.25 cm. On the 14th the temperature at 9 a. m. was -3° C. and increased to -1° C. at 1 p. m. then decreased to -4° at 5 p. m. while the hourly evaporation increased from 0.168 cm. to 0.180 cm. then decreased to 0.166 cm.

The table also shows that the hourly evaporation increases as the velocity of the wind increases. On the 12th with a velocity of one unit and at 1 p. m. with temperature -3° C. and pressure 30 in the hourly evaporation was 0.17 cm.,On the 14th at 3 p. m. with same temperature and approximately same pressure, but velocity of wind two units, the hourly evaporation was 0.172 cm. On the 13th with conditions about the same at 1 p. m., but wind velocity of four units, the hourly evaporation was 0.238 cm. The large evaporation for the 12th was due in part without doubt to the increased pressure, showing that the amount of evaporation depends upon the clear condition of the atmosphere, such as usually accompanies a great pressure.

On the 17th of March an experiment was commenced in the same way with snow in place of ice and was carried on in a similar manner.

TABLE 30.—*Data for evaporation of snow.*

Date 1906.	Hour.	Temperature C.	Pressure.	Height of snow.	Loss in weight per hr.	Remarks.
Mar. 17..	9	—2.	29.82	42.90		Wind W.
	10	—3.	29.83	42.39	.510	Vel. 2.
	11	—2.2	29.84	41.885	.505	
	12	—0.8	29.84	41.363	.522	
	1	—1.	29.85	40.840	.523	No clouds.
	2	—1.3	29.85	40.320	.520	Average loss per hr. .512.
	3	—1.9	29.85	39.810	.510	
	4	—2.6	29.86	39.300	.510	
Mar. 18..	9	—14.	30 05	45.300		New lot of snow.
	10	—12.5	30.05	44.880	.420	
	11	—11.5	30.06	44.444	.436	Wind N. W.
	12	—10.3	30.05	43.999	.445	Vel. 4.
	1	—10.	30.04	43.449	.450	Cloudy.
	2	— 9.1	30.04	42.991	.458	Average loss per hr. .451.
	3	— 8.	30.03	42.531	.460	
	4	— 7.	30.02	42.046	.485	
Mar. 19..	9	—10.	30.01	33.761	.435	Wind N. W.
	10	— 8.	30.02	33.541	.510	Vel. 5.
	11	— 8.6	30.03	32.735	.516	
	12	— 7.5	30.03	32.215	.520	
	1	— 6.9	30.02	32.685	.530	No clouds.
	2	— 6.3	30.03	32.149	.536	Average loss per hour .507.
	3	— 5.8	30.04	31.608	.541	
	4	— 5.	30.06	31.058	.550	

The temperature for the three days during which this part of the experiment was continued remained at all times below 0° C. There was quite a high wind during a greater part of the time and the effect of wind upon the evaporation may easily be seen. The amount of evaporation increased considerably with an increase of wind velocity.

The snow was put into the wire receiver very lightly so as not to diminish the size of the pores or space between the crystals.

The wind caused the index to vibrate up and down so that it was necessary to make the readings by the method of vibrations. This is why the distance is carried out to the third decimal place.

The iron wire made a very delicate means of detecting the loss in weight. The length of the wire was about three feet so that a very small decrease in weight made a large difference in the height of the index.

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